

DOCUMENT A00803

**APPENDIX A**

**MBTA CONSTRUCTION SPECIFICATIONS**

**FOR**

**BUS RAPID TRANSIT**

**STATION CONSTRUCTION**

**MASSACHUSETTS BAY TRANSPORTATION AUTHORITY**  
**CONSTRUCTION SPECIFICATIONS**  
**FOR BUS RAPID TRANSIT STATION CONSTRUCTION**

**APPENDIX A**

**SUPPLEMENTING MASSDOT SPECIAL PROVISIONS**  
**SILVER LINE GATEWAY**  
**CHELSEA, MA**

**MASSDOT PROJECT FILE NO. 604428**

**FOREWORD**

*The MBTA's Standard Plans referred to herein is the book of plans entitled "MBTA Railroad Operations – Book of Standard Plans – Track and Roadway"; which is available for download on MBTA.com. Also, the MBTA's Standard Plan entitled "MBTA Railroad Operations – Commuter Rail Design Standards Manual" is available for download on MBTA.com Bidding documents are available for download from an MBTA FTP site, or on a CD via Fed Ex. Interested parties must complete the Project Plans Request Form on individual project pages at: [http://www.mbt.com/business\\_center/bidding\\_solicitations/current\\_solicitations/](http://www.mbt.com/business_center/bidding_solicitations/current_solicitations/)*

*Plans referenced in this book are referred to as STANDARD PLAN (Number).*

# **CONSTRUCTION SPECIFICATIONS TABLE OF CONTENTS**

<b>SECTION</b>	<b>NO. OF PAGE</b>
<b>DIVISION 1 – GENERAL REQUIREMENTS</b>	
01010 SUMMARY OF WORK	3
<b>DIVISION 2 – SITE WORK</b>	
02470 SITE IMPROVEMENTS	3
<b>DIVISION 3 - CONCRETE</b>	
03300 CAST IN PLACE CONCRETE	20
<b>DIVISION 5 - METALS</b>	
05041 HOT-DIP GALVANIZING	3
05100 STRUCTURAL STEEL	10
05500 MISCELLANEOUS METALS	10
<b>DIVISION 6 - WOOD</b>	
06100 CARPENTRY	5
<b>DIVISION 7 - THERMAL AND MOISTURE PROTECTION</b>	
07500 MEMBRANE ROOFING	7
07600 FLASHING AND SHEET METALS	6
<b>DIVISION 8 - DOORS AND WINDOWS</b>	
08801 GLASS AND GLAZING	11
<b>DIVISION 9 - FINISHES</b>	
09360 MODULAR TACTILE SURFACES	8
09861 ANTI GRAFFITI COATINGS	6

**DIVISION 10 -SPECIALTIES**

10100	DISPLAY CASES	6
10400	FIXED SIGNAGE	12
10426	TACTILE/BRAILLE SIGNAGE	8
10428	MBTA LOLLIPOP SIGN	8
10450	FARE COLLECTION EQUIPMENT	5

**DIVISION 13 – SPECIAL CONSTRUCTION**

13126	PREFABRICATED BOOTHS	10
13127	MBTA TEMPORARY COMFORT STATION	3
13700	ELECTRONIC ACCESS CONTROL SYSTEM	20
13710	IP INTERCOM PASSENGER ASSISTANCE TELEPHONE	10

**DIVISION 16 -ELECTRICAL**

16050	BASIC MATERIALS AND METHODS FOR ELECTRICAL WORK	22
16195	ELECTRICAL IDENTIFICATION	4
16325	CONDUIT SYSTEM	6
16410	SURGE PROTECTION DEVICES	8
16450	GROUNDING	6
16471	DISTRIBUTION AND BRANCH CIRCUIT PANELBOARDS	6
16500	LIGHTING	14
16700	POWER WIRE AND CABLE	10
16749	FIBER OPTIC CABLE SYSTEMS	8
16770	PASSENGER STATION VARIABLE MESSAGE SIGNS	10
16840	CLOSED CIRCUIT TELEVISION SYSTEM	28
16844	COMMUNICATION SYSTEM JUNCTION BOXES	2
16876	COMMUNICATIONS GROUNDING OF EQUIPMENT	2
16881	PUBLIC ADDRESS SYSTEM	14
16898	COMMUNICATION SYSTEMS TESTS	26

## **SECTION 01010**

### **SUMMARY OF THE WORK**

#### **GENERAL**

#### **GENERAL**

The Work shall be performed in accordance with the following documents as issued by the Massachusetts Department of Transportation (MassDOT):

The Standard Specifications which includes the Instructions to Bidders, and General Conditions.

The Contract Special Provisions which includes the Notice to Bidders; Instructions to Bidders; Federal and State requirements.

The Supplemental MBTA Construction Specifications contained herein

The Contract Drawings.

#### **1.1 CONTRACT DESCRIPTION, COMMENCEMENT AND COMPLETION TIMES**

##### **A. Description**

The Project consists of the construction of the Silver Line Gateway Project in Chelsea. Work under these supplemental MBTA Specifications consists of construction of the Bus Rapid Transit Stations, including, but not limited to, construction of new platforms, canopies, passenger shelters signage, communications systems, lighting systems and security systems.

#### **1.03 CONSTRUCTION PHASING**

- A. Construction Phasing of the work shall be planned in such a manner that will maintain uninterrupted existing operations of the MBTA Commuter Rail Service, operated by Keolis Commuter Services, as well as freight operations.
- B. Construction Phasing of the work shall also be planned in such a manner that will maintain uninterrupted operations of the existing Chelsea Commuter Rail Station, located between Arlington Street and Washington Avenue. The Contractor shall prepare a detailed construction plan for submission to the MBTA on how commuter rail passenger services will be maintained at the station during construction. .
- C. The Contractor shall coordinate all construction activities with the appropriate agencies of the City of Chelsea, and shall avoid construction related impacts on the adjacent and adjoining areas.
- D. All necessary and required permits and approvals from the City of Chelsea shall be obtained by Contractor. All other necessary and required approvals from the MBTA, MBCR, utility companies, abutters, etc. shall also be obtained by Contractor

#### **1.04 LIMITS OF WORK AND ACCESS TO SITES OF WORK**

- A. The Contractor is to restrict work to MBTA, or State owned areas or areas within a public right-of-way. However, any additional areas which the Contractor might require, shall be secured by the Contractor at the sole expense and responsibility of the Contractor, but written evidence thereof shall be furnished to the MassDOT. Prior approval from the MassDOT and the owner will be required.
- B. Prior to the commencement of construction, the Contractor shall present the Authority with a detailed plan of how he will perform the work on this project without impacting Commuter Rail Service and Railroad Operations. The plan should also identify how materials and equipment will be delivered to the construction site. This plan cannot be implemented until it is approved by the Authority.
- C. Contractor will not be allowed to work within the “foul” area of the railroad (15 feet, or the potential to be within 15 feet, from centerline of track) without flagmen and/or track foremen present from the operating railroad.
- D. Contractor shall be responsible for coordinating with the local utility companies for relocation of their facilities as required for the construction of all work.

#### **1.05 EXISTING CONSTRUCTION AND CONDITIONS**

- A. The MassDOT believes that information on the drawings describing existing construction or conditions is correct insofar as it is shown; however, it does not guarantee or represent that existing construction, utilities or conditions conform to the drawings. The Contractor shall visit the site and satisfy himself as to the existing conditions. No claim for extra cost will be allowed because of the Contractor's unfamiliarity with observable site conditions.
- B. In case of discrepancies being found in the Contract Documents, the Contractor shall immediately report them to the Engineer and shall commence no new work nor place orders concerned with the matter in doubt until resolution is made by the Engineer.

#### **1.06 REPAIRING AND REPLACING EXISTING WORK**

- A. The Contractor shall work through the Engineer to obtain the necessary coordination with the Operation and Maintenance Departments of the Authority in order to permit construction progress with the most possible cooperation. MBTA commuter service shall be maintained uninterrupted. Furthermore, the Contractor shall coordinate his efforts with other Contractors working on separate contracts in the immediate vicinity of the construction sites.

#### **1.07 WARRANTY OF WORK**

- A. Neither final acceptance, final payment nor any provision in the Contract Documents nor partial or entire use or occupancy of the premises by the Authority shall constitute an acceptance of work not done in accordance with the Contract Documents or relieve the Contractor of liability with respect to any express warranties or responsibility for faulty materials or workmanship.

Except where longer periods of warranty are specified for certain items, the Contractor warrants all work done under the Contract to be free from faulty materials and workmanship for a period of one year from date of acceptance thereof.

Upon receiving notification from the Authority, the Contractor shall immediately make the required repairs or replacements to any work found defective. If repairs or replacements are not started within 10 days from the date of notification and prosecuted to completion, the Authority reserves the right to employ others to complete the Work. The Contractor agrees, upon demand, to pay the Authority all amounts which it expends for such repairs or replacements.

All remedied Work shall carry the same warranty as the original work starting with the date of acceptable replacement or repair.

## **PRODUCTS**

## **EXECUTION**

## **MEASUREMENT AND PAYMENT**

Not Used.

## **END OF SECTION**

## **SECTION 02470**

### **SITE IMPROVEMENTS**

#### **PART 1 - GENERAL**

##### **1.01 DESCRIPTION**

- A. This Section specifies furnishing and installation of miscellaneous site improvements including bicycle shelters, benches and trash receptacles.
- B. Concrete, concrete reinforcement, miscellaneous metals and incidentals thereto shall conform to the applicable requirements of the Contract Specification Sections 03300, 05041 and 05500.

##### **1.02 SUBMITTALS**

- A. Shop Drawings
  - 1. Submit shop drawings and samples for the bicycle racks for review and approval prior to fabrication.
  - 2. Submit shop drawings including catalog cuts and literature for benches.
  - 3. Submit detailed shop drawings of product including overall dimensions and options including catalog cuts, literature and full range of material samples for color selection for trash receptacles.

#### **PART 2 - PRODUCTS**

##### **2.01 BICYCLE SHELTERS**

- A. The bicycle shelter frames shall be heavy duty high quality ASTM36 Schedule 40 steel framing, with dimensions as shown on the Contract Drawings. Finishes galvanized steel with Color Galvanized finish. The bicycle rack shall provide lock supports per ASTM A-36. The entire rack shall be galvanized with black powder coated finish, after fabrication.
- B. The bicycle shelter shall have a Translucent polycarbonate PCSS-clear opal roof structures to the dimensions shown on the Drawings
- C. Concrete foundations shall be Class 5000.
- D. All hardware shall be fabricated from steel and galvanized after fabrication.

##### **2.02 BENCHES**

- A. The benches shall consist of materials and dimensions as shown on the Contract Drawings. Basis of Design is Tangent Rail Seating by Fors+Surfaces. Custom powder-coated color for each of the 4 Stations as selected by the Engineer.

##### **2.03 TRASH RECEPTACLES**



- A. Trash receptacles shall be solar powered cordless compaction systems, measuring 26" long by 26" wide by 50" high with a bin size of 35 gallons. Trash receptacles shall be fabricated of galvanized sheet metal with heavy duty plastic side panels. Exterior finish shall be of polyester TGIC powder-coated finish with salt-spray durability. Solar panel shall cordless self powered unit, consisting of polycrystalline silicon cell PV module, 30 watts, 12 volts DC.

## **PART 3 - EXECUTION**

### **3.01 BICYCLE SHELTERS**

- A. Work shall be executed only by workmen experienced in the trade.
- B. Obtain exact dimensions, cut, fit and drill as necessary for proper assembly and installation of all work and for attaching items of other trades as required.
- C. All steel fabrication, including any welding and dressing, shall be completed before galvanizing.
- E. Welding shall conform to the applicable requirements of AWS D1.1. All groove welds shall be ground flush and smooth.
- F. Install shelter vertical members level and plumb at the locations indicated on the Contract Drawings and in accordance with approved shop drawings. Coordinate rack installation with installation of the surrounding surface at grade beneath the racks until adjacent work is completed. Repair all damage to the finish in a manner consistent with the manufacturer's recommendations.
- G. Protect racks from paint spatter, splashed concrete and other construction damage by wrapping and taping in place plastic sheeting or heavy kraft paper around the racks until adjacent work is completed. Repair all damage to the painted finish in manner consistent with the manufacturer's recommendations and with the original bicycle rack paint.

### **3.02 BENCHES**

- A. Benches shall be mounted as recommended by the manufacturer and as shown on the drawings and approved shop drawings.
- B. Shim benches as necessary with stainless steel shims to install level and plumb.

### **3.03 TRASH RECEPTACLES**

- A. Preparation: Lay out units in the field for approval from the Engineer for precise location prior to installation.
- B. Installation: Trash receptacles shall be bolted to the concrete surface in accordance with the manufacturer's recommendations and specifications.

- C. Protection: Provide temporary protection for completed work until final acceptance. Remove protections and re-clean as necessary, immediately before final acceptance.

#### **PART 4 - MEASUREMENT AND PAYMENT**

##### **4.01 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Station. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of Site Improvements including Bicycle Shelters, Benches and Trash Receptacles for the BRT Stations.

**END OF SECTION**

**SECTION 03300**  
**CAST-IN-PLACE CONCRETE**

**PART 1 - GENERAL**

**1.1 DESCRIPTION OF WORK**

- A. Work Included: This Section specifies the following items:
1. Cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures and finishes for the following applications:
    - a. Footings.
    - b. Foundation walls.
    - c. Concrete Canopy Structures at Bus Rapid Transit Stations
    - d. Concrete Platforms for Bus Rapid Transit Stations
    - e. Concrete long span arches at Box District Station
- B. Items To Be Installed Only: Install the following items as furnished by the designated Sections:
1. Section 05100 - STRUCTURAL STEEL:
    - a. Lintels, sleeves, anchors, inserts, embedded wall plates, loose leveling plates and similar items.
  2. Section 05500 - MISCELLANEOUS METALS:
    - a. Lintels, sleeves, anchors, inserts, plates and similar items for miscellaneous and ornamental metal.
  3. Division 16 - ELECTRICAL:
    - a. Lintels, sleeves, anchors, inserts, plates, floor boxes and similar items for electrical systems.
- C. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
1. Section 08801 – GLASS AND GLAZING; canopy roof structure.
  2. Section 09861 – ANTI-GRAFFITI COATINGS: finish treatment

**1.2 DEFINITIONS**

- A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume; subject to compliance with requirements.

### **1.3 SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Design Mixtures: For each concrete mixture, submit proposed mix proportions and test results confirming mix meets requirements stated below. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
  - 1. Indicate amounts of mixing water to be withheld for later addition at Project site.
- C. Steel Reinforcement Shop Drawings: Placing drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement.
  - 1. Indicate coordination requirements for reinforcement locations with requirements of structural steel, steel joints and steel deck.
- D. Formwork Shop Drawings: Prepared by or under the supervision of a qualified professional engineer licensed in the Commonwealth of Massachusetts detailing fabrication, assembly, and support of formwork.
  - 1. Shoring and Reshoring: Indicate proposed schedule and sequence of stripping formwork, shoring removal, and installing and removing reshoring.
  - 2. Blockouts for Architectural Joint Systems: Indicate blockouts and coordination with architectural joint systems.
- E. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:
  - 1. Aggregates.
- F. Material Certificates: For each of the following, signed by manufacturers:
  - 1. Cementitious materials.
  - 2. Admixtures.
  - 3. Form materials and form-release agents.
  - 4. Steel reinforcement and accessories.
  - 5. Fiber reinforcement.
  - 6. Waterstops.
  - 7. Curing compounds.
  - 8. Floor and slab treatments.
  - 9. Bonding agents.
  - 10. Adhesives.
  - 11. Vapor retarders.
  - 12. Semirigid joint filler.
  - 13. Joint-filler strips.
  - 14. Repair materials.

- G. Floor surface flatness and levelness measurements to determine compliance with specified tolerances and requirements for applied finishes and materials, except as noted for slope to drains.
- H. Field quality-control test and inspection reports.
- I. Minutes of preinstallation conference.

#### **1.4 QUALITY CONTROL /QUALITY ASSURANCE**

- A. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment. Manufacturer shall be responsible for sampling and testing of concrete ingredients and establishing concrete mix proportions.
- B. Testing and Inspection Services by the Authority: Concrete plant inspection; and field control will be by the Authority at the expense of the Authority.
  - 1. The Contractor agrees to accept as indicative, the results of tests, including test results involving mix designs and field quality control of concrete mixtures. If, as a result of these tests, it is determined that the specified concrete properties are not being obtained, the Engineer may order such changes in proportions or materials, or both, as may be necessary to secure the specified properties, at no additional expense to the Authority.
  - 2. The use of testing and inspection services shall in no way relieve the Contractor of his responsibility to furnish materials and construction in compliance with the Contract Documents.
  - 3. Failure to detect any defective work or material shall not in any way prevent later rejection when such defect is discovered nor shall it obligate the Engineer for final acceptance.
  - 4. Additional testing and inspection services requested by the Contractor because of changes in materials, sources, or proportions, or occasioned by failure of tests and inspection to meet specification requirements, shall be paid for by the Contractor. The costs for such additional testing and inspection services will be established by the Engineer.
    - a. Provide at no additional expense to the Authority all materials, labor, and services for sampling and testing required by the Engineer, including but not limited to:
    - b. Transportation of sample materials from source to the Authority's Materials Testing Laboratory.
    - c. Preparation, handling, storage and transportation of concrete test specimens as directed by the Engineer.
    - d. Suitable containers for the storage, curing and transportation of concrete test specimens in accordance with ASTM C 31.
    - e. Suitable storage for a supply of test cylinder molds, test equipment and other items required for sampling and testing.
- C. When additional sets of test cylinders beyond the mandatory seven and twenty-eight day tests are required by the Contractor to verify early form removal or other reasons for his benefit, the Authority shall be reimbursed for the cost of fabricating and testing these additional test

cylinders. The Contractor has the option of obtaining additional test services from an independent testing laboratory agency approved by the Engineer. Copies of test data from these additional tests shall be submitted to the Engineer for review and approval.

- D. The minimum number of test cylinders to be made for each class of concrete and for each placement will be four for each 100 cubic yards or less and minimum of four extra cylinders for each additional 50 cubic yards or fraction thereof. When additional sets of test cylinders are required beyond the normal seven and twenty-eight day tests, each set will consist of a minimum of two test cylinders.
- E. Independent Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.
  - 1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-01 or an equivalent certification program.
  - 2. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician - Grade I. Testing Agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician - Grade II.
- F. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from one source, and obtain admixtures through one source from a single manufacturer.
- G. Welding: Qualify procedures and personnel according to AWS D1.4, "Structural Welding Code--Reinforcing Steel".
- H. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:
  - 1. ACI 301, "Specification for Structural Concrete".
  - 2. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials".
- I. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.
- J. Preinstallation Conference: Conduct conference at Project site to address the following:
  - 1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:
    - a. Contractor's superintendent.
    - b. Independent testing agency responsible for concrete design mixtures.
    - c. Ready-mix concrete manufacturer.
    - d. Concrete subcontractor.
  - 2. Review special inspection and testing and inspecting agency procedures for field quality control, concrete finishes and finishing, cold- and hot-weather concreting procedures, curing procedures, construction contraction and isolation joints, and joint-filler strips,

semirigid joint fillers, forms and form removal limitations, shoring and reshoring procedures, vapor-retarder installation, anchor rod and anchorage device installation tolerances, steel reinforcement installation, floor and slab flatness and levelness measurement, concrete repair procedures, and concrete protection.

## 1.5 DELIVERY, STORAGE, AND HANDLING

- A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage. Avoid damaging coatings on steel reinforcement.
- B. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

## PART 2 - PRODUCTS

### 2.1 CONCRETE MATERIALS

- A. Cement: Shall be American-made Portland Cement, free from water soluble salts or alkalis which will cause efflorescence on exposed surfaces. Portland Cement shall be Type II, ASTM C 150. Use only one brand of cement for each type of cement throughout project. Contractor shall be responsible for whatever steps are necessary to insure that no visual variations in color will result in exposed concrete and shall place on order and secure in advance a sufficient quantity of this (these) cement(s) to complete concrete work specified herein.
  - 1. Fly Ash: ASTM C 618, Type F 15-35%
  - 2. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120, 25-50%
- B. Normal Weight Fine Aggregate: Shall be washed, inert, natural sand conforming to ASTM C 33 and following additional requirements:

<u>Sieve</u>	<u>Percent Passing</u>
#4	95-100 (typical)
#16	50-85
#50	5-30
#100	0-10
Fineness Modulus	2.80 (Plus/Minus 0.20)
Organic	Plate 2 maximum
Silt	2.0 percent maximum
Mortar Strength	100 percent minimum compression ratio
Soundness	15 percent maximum loss, magnesium sulfate, five cycles

- C. Normal Weight Coarse Aggregate: Shall be well graded crushed stone or washed gravel conforming to ASTM C 33 and the following additional requirements:

Designated Size (inches)	3	2	1-1/2	1	3/4	1/2	3/8
F.M. (+/-0.20)	7.95	7.45	7.20	6.95	6.70	6.10	4.50

Organic	Plate 1 maximum
Silt	1.0 percent maximum
Soundness	5 percent maximum loss, magnesium sulfate, five cycles

- D. Maximum designated sizes for normal weight coarse aggregate to be used in concrete sections shall be as noted below, except that sizes shall also be chosen in conjunction with required clearances.
1. One and one-half inches for sections over ten inches in thickness.
  2. One inch for sections more than eight and up to ten inches in thickness.
  3. Three-quarter inch for sections more than three and up to eight inches in thickness.
- E. Concrete Fill for Steel Stair and Landing Pans: Composed of 1:2:2 mix with three-eighths inch maximum size normal weight aggregate and shall be placed with a 0 inches to 1 inch slump.
- F. Water: From approved source, potable, clean and free from oils, acids, alkali, organic matter and other deleterious material and complying with the requirements of ASTM C 94.
- G. Admixtures:
1. Water-reducing agent:
    - a. "WRDA" - W.R. Grace & Co.
    - b. "PDA25" - Protex Industries, Inc.
    - c. "Pozzolith 344H" - Master Builder's Co.
    - d. Or approved equivalent
    - e. Note: Water-reducing agent shall be by same manufacturer as air-entraining agent.
  2. Air-entraining agent:
    - a. "DAREX AEA" - W.R. Grace & Co.
    - b. "PROTEX AEA" - Protex Industries
    - c. "MB-VR" or "MB-AE" - Master Builder's Co.
    - d. Or approved equivalent
  3. Superplasticizer: High-range water-reducer conforming to ASTM C 494, Type F or Type G.
  4. Admixtures retarding setting of cement in concrete shall not be used without written approval of Engineer.
  5. Admixtures causing accelerated setting of cement in concrete shall not be used without written approval of Engineer.

## 2.2 CONCRETE MIXTURES

- A. The Contractor shall recommend, on the basis of trial mixes and strength curves specified below, design mixes for each type and strength of concrete. The Testing Agency will verify that the proposed mix designs conform to all specification requirements.
- B. Sufficient materials for concrete mix design shall be furnished by Contractor not less than five weeks before use. Duplicate small samples plainly and neatly labeled with source, where



proposed to be used, date, and name of collector shall be provided and presented to Testing Agency for permanent reference.

- C. Mixes shall be designed in accordance with "Method 1" of ACI 301, and the requirements of this Section. All concrete is normal weight unless specifically designated otherwise; air-dry weight not to exceed 150 lbs. per cubic foot.
- D. All structural concrete shall have a minimum 28 day compressive strength of 4,000 psi.
- E. Exterior concrete shall contain air-entraining admixture when tested to ASTM C 231 at the point of discharge from the truck mixer:

<u>Aggregate Size</u>	<u>Air Content, %</u>
1-1/2 in.	4.5 - 7.5
3/4 in.	5.0 - 8.0
3/8 in.	6.0 - 9.0

- F. Concrete shall have the following slump when tested to ASTM C 143 at the point of discharge from the truck mixer:

<u>Condition</u>	<u>Slump, inches</u>
With Water-Reducing Agent	4-1/2 - 7
With High-Range W/R Agent	7-9
Without Water-Reducing Agent	2 - 5

- G. Concrete slabs, including slabs on grade, shall have a mid-range water reducer and have a maximum slump of 6 inches.
- H. The approved superplasticizer shall be used in all concrete walls, including slabs on grade.
- I. Design mix of concrete to be used in work shall correspond to following test strengths (TABLE A) obtained in laboratory trial mixtures.

TABLE A

Minimum Strength of Lab Trial Mixes (psi)

Design Strength	Trial Mix Strength	
	7-days	28-days
4000	3400	5200
5000	4200	6200

- J. Any deviation from approved mix design, which Contractor deems desirable under certain project conditions, will not be allowed without written approval of Engineer. Cost of any additional testing by Testing Agency associated therewith shall be paid for by Contractor.

## **2.3 FORM MATERIALS**

- A. Construct formwork to shapes, lines, and dimensions required, plumb and straight, secured and braced sufficiently rigid to prevent deformation under load, and sufficiently tight to prevent leakage, all in conformance with ACI Standard 347, "Recommended Practice for Concrete Formwork".
- B. Formwork for exposed concrete shall be medium-density plastic overlaid plywood, 5/8" minimum thickness; for concealed concrete shall be "Plyform" plywood, 5/8" minimum thickness.
- C. Chamfer Strips: Half-inch, 45 degree poplar wood strips, nailed six inches on center, and installed in inside corners of all forms, unless otherwise directed by Engineer.
- D. Form Ties and Spreaders: Richmond Tyscrus by Richmond Screw Anchor Co.; Superior-ties by Superior Concrete Accessories, Ind.; or Sure-Grip Ties by Dayton Sure-Grip and Shore Co. Wire ties shall not be used. Ties for foundation walls shall be snap-ties or type specified above with removal cones and shall incorporate water seal washer. Ties shall be arranged in a symmetrical manner.
- E. Form Release Agent: Non-staining and non-emulsifiable type, or equal approved by Engineer. Form release agent shall be biodegradable and shall not impart any stain to concrete nor interfere with adherence of any material to be applied to concrete surfaces.

## **2.4 REINFORCEMENT AND ACCESSORIES**

- A. Reinforcing Steel Bars: Shall be newly rolled billet steel conforming to ASTM A 615 Grade 60. Bars shall be bent cold.
- B. Welded Wire Fabric: Shall conform to ASTM A 185.
- C. All hot-dip galvanized steel, when specified on drawings, shall be inspected for compliance with ASTM A 123 and shall be marked with a stamp that indicates the number of ounces of zinc per square foot of steel. After galvanizing, the bars shall be dipped in a 0.2 percent chromic acid solution. A notarized Certificate of Compliance with all of the above shall be required from the galvanizer.
- D. Reinforcement Accessories: Shall conform to Product Standard PS7-766, National Bureau of Standards, Department of Commerce, Class C, as produced by Superior Concrete Accessories, Inc.; Dayton Sure-Grip Co.; or R.K.L. Building Specialties Co., Inc. Reinforcement accessories shall include spacers, chairs, ties, slab bolsters, clips, chair bars, and other devices for properly assembling, placing, spacing, supporting, and fastening reinforcement. Tie wire shall be galvanized or stainless wire of sufficient strength for intended purpose, but not less than No. 18 gage. Metal supports shall be of such type as not to penetrate surface of formwork and show through surface of concrete. Accessories touching interior formed surfaces exposed to view shall have not less than 1/8 inch of plastic between metal and concrete surface. Plastic tips shall extend not less than 1/2 inch up on metal legs. Individual and continuous slab bolsters and chairs shall be of type to suit various conditions encountered and must be capable of supporting 300 pound load without damage or permanent distortion.

## 2.5 MISCELLANEOUS MATERIALS

- A. Grout: Ready-to-use aggregate product requiring only addition of water at job site such as "Embeco Pre-mixed Grout" by Master Builder's; "Vibro-Foil Ready-Mixed" by W.R. Grace & Co.; or "Ferrolith G" by Sonneborn Building Products, Inc. Grout shall be easily workable and shall have no drying shrinkage at any age. Compressive strength of grout (2" x 2" cubes) shall not be less than 5000 psi at 7 days, and 7500 psi at 28 days.
- B. Waterstops: Extruded virgin PVC containing no scrap or reclaimed material or pigment. Provide cross section as indicated, uniform along the length of the waterstop and symmetrical transversely so that the thickness at any given distance from either edge of the waterstop will be uniform. The finished waterstop shall meet the requirements specified below for the average of five samples tested in each case. Report standard deviations of values in addition to averages. Condition and test samples in atmosphere of 73 (plus or minus 3) degrees F and 50 (plus or minus 10) percent relative humidity, except where other test conditions are specified.
  - 1. Tensile strength, per ASTM D 638. Die IV-: 2000 psi. minimum.
  - 2. Ultimate elongation, per ASTM D 638. Die IV: 350 percent, minimum.
  - 3. Tear resistance, per ASTM D 624. Die B: 350 pounds per inch of thickness, minimum
  - 4. Stiffness in flexure, samples reduced to 1/8-inch thickness, per ASTM D 747. 1/4 inch span: 600 psi. minimum.
  - 5. Low temperature brittleness samples reduced to 1/8-inch thickness, per ASTM D 746: no cracking, chipping, or sign of failure at minus 35 degrees F.
  - 6. Accelerated Extraction, samples reduced to 1/8-inch thickness, per Corps of Engineers CRDC-572: tensile strength, per ASTM D 412. Die C 1750 psi. minimum; ultimate elongation, per ASTM D 412. Die C: 300 percent, minimum.
  - 7. Effect of Alkali, samples reduced to 1/8-inch thickness, per Corps of Engineers CRDC-572: Change in weight. 7 days: minus 0.10 to plus 0.25 percent; Change in weight. 30 days minus 0.10 to plus 0.25 percent; Change in hardness. 7 days. per ASTM D 2240. Shore A-2: plus or minus 5 points; Change in thickness. 30 days: plus or minus 1.0 percent.
  - 8. Tensile strength of samples taken across site-made and factory-made splices, per ASTM D 638 Die I \1000 psi. minimum
- C. Vapor Barrier: 6 mil polyethylene, unless specifically specified elsewhere.
- D. Membrane Curing Compound: ASTM C 309, Type 1. Product used shall be shown to be compatible with the later application of coatings. Curing compound shall not be used on any floor slab scheduled to receive an adhered floor finish.
- E. Membrane Curing Compound for Architectural Concrete: Liquid membrane curing compound complying with AASHTO M148, Type 1D, except Type 2 if required to control temperature of mass concrete and hot weather concrete.
- F. Sheet Curing Materials: Waterproof paper (regular or white), polyethylene film (clear or opaque white), and white burlap-polyethylene sheet complying with AASHTO M171.
- G. Chemical Hardener: All exposed concrete floor slabs shall be hardened with three applications of fluosilicate chemical hardener followed by two applications of clear acrylic concrete sealer

by Sonneborn Division, ChemRex Inc. "Lapidolith"; or equal products by W.R. Meadows Co. and Concrete Service Material Company or other manufacturers.

- H. Penetrating Sealer: Monomeric alkyalkoxy silane sealer which has demonstrated penetrability into dry low permeability concrete to a minimum of 1/4 inch. Sealer shall have 20 to 25 percent solids when used on walls, and 40 to 50 percent solids when used on floors.
- I. Epoxy Membrane Curing Compound/Concrete Sealer: The two component, epoxy resin system shall act as a dual purpose material: A membrane compound for curing alone, plus a penetrating sealer. It shall provide protection for concrete exposed to de-icing salts, commercial acids and alkalis, gasoline, diesel fuel, and oil, and exposure to freeze/thaw cycles and to vehicular traffic. The epoxy resin compound shall be furnished in two components for combining immediately prior to use in accordance with the manufacturer's written instructions as specified herein. The components of the epoxy resin system shall conform to the following requirements.
  - 1. Component A: Poly (2 hydroxypropylene, P'p, isopropylidenephénolate) condensed with 1 chlorepropoxirane such that the ox content is 4% in aralkyl and hydroxylated solvents. Component B: The amido amine condensate of the Diels Alder adduct of polyunsaturated acids dissolved in suitable solvents. Ratio of components (A to B): 1:1 by volume.
  - 2. Properties of Mixed Material:
    - a. Viscosity: 75 to 125 cP's at 75°F.
    - b. Pot Life: 8 hours minimum at 75°F.
    - c. Minimum Solids Content: 40 to 44% by weight.
    - d. Recoat Time: 24 hours maximum.
    - e. Dry Film Thickness: 2 to 3 mils per coat.
    - f. Color: Clear, White tint, gray tint.
  - 3. Properties of Cured Material:
    - a. The cured system shall exhibit no evidence of a mine blushing or sweating which may inhibit bond of subsequent coats.
    - b. When tested according to ASTM D 968, specimens of coating cured for 14 days at 75°F shall exhibit an abrasion coefficient of at least 30 liters per mil.
    - c. When tested according to ASTM D 522, a 2 mil dry film thickness specimen cured for 14 days at 75° shall exceed 12% elongation when tested on the 1/4 inch mandrel.
    - d. Specimens cured for 14 days at 75°F and immersed for 48 hours shall exhibit less than 1% water absorption by weight.
    - e. Water Retentivity shall not exceed 0.055 grams per square centimeter when tested according to ASTM C 156.

## **PART 3 - EXECUTION**

### **3.1 INSPECTION**

- A. Examine all work prepared by others to receive work of this Section. Commencement of work will be construed as complete acceptance of preparatory work by others.
  - 1. Hold Point-A pre-placement inspection shall be performed by the Contractor prior to placing concrete to assure that placement prerequisites have been accomplished.

### **3.2 HANDLING, STORAGE, AND PROTECTION OF MATERIALS**

- A. Handle and store materials separately in such manner as to prevent intrusion of foreign matter, segregation, or deterioration. Do not use foreign materials or those containing ice. Remove improper and rejected materials immediately from point of use. Cover materials, including steel reinforcement and accessories, during construction period. Stockpile concrete constituents properly to assure uniformity throughout project.

### **3.3 ERECTION OF FORMWORK, SHORING AND RESHORING**

- A. Set and maintain formwork to insure complete concrete work within tolerance limits listed in ACI 347 latest edition, "Recommended Practice for Concrete Formwork", and with following additional requirements:
  - 1. Maximum variations from plumb:
    - a. In surfaces of columns and walls:
      - 1) In any 10 feet of length: 1/4 inch
      - 2) Maximum for entire length: 1/2 inch
  - 2. Maximum variations from established position in plan shown on the drawings:
    - a. Column: 1/2 inch
    - b. Walls: 3/4 inch
  - 3. Variations in cross-sectional dimensions of columns and beams and in thickness of slabs and walls.
    - a. Minus: 1/8 inch
    - b. Plus: 1/4 inch
- B. Before form materials can be re-used, surfaces that will be in contact with freshly cast concrete shall be thoroughly cleaned, damaged areas repaired and projecting nails withdrawn. Re-use of form material shall be subject to approval by Engineer.

### **3.4 PLACING OF REINFORCEMENT**

- A. Reinforcement shall be placed in accordance with requirements of CRSI 93, "Recommended Practice for Placing Reinforcing Bars" and CRSI 93, "Recommended Practice for Placing Bar Supports" and with further requirements below.
- B. Reinforcement shall be accurately placed in accordance with Contract Documents and shall be firmly secured in position by wire ties, chairs, spacers, and hangers, each of type approved by Engineer.
- C. Bending, welding or cutting reinforcement in field in any manner other than as shown on Drawings, is prohibited, unless specific approval for each case is given by Engineer.
- D. Reinforcement shall be continuous through construction joints unless otherwise indicated on Drawings.
- E. Reinforcement shall be spliced only in accordance with requirements of Contract Documents or as otherwise specifically approved by Engineer. Splices of reinforcement at points of maximum stress shall generally be avoided. Welded wire fabric shall lap six inches or one space plus two inches whichever is larger, and shall be wired together.
- F. At time concrete is placed, reinforcement shall be free of excessive rust, scale, or other coatings that will destroy or reduce bond requirements. Reinforcement expected to be exposed to weather for a considerable length of time shall be painted with a heavy coat of cement grout. Protect stored materials so as not to bend or distort bars in any way. Bars that become damaged will be rejected.
- G. Hold Point - Before concrete is cast, check all reinforcement after it is placed to insure that reinforcement conforms to Contract Documents and approved Shop Drawings. The Engineer shall be notified at least 36 hours prior to concrete placement and given opportunity to inspect completed reinforcement and formwork before concrete placement. Prior approval of Shop Drawings shall in no way limit Engineer's right to demand modifications or additions to reinforcement or accessories.

### **3.5 JOINTS**

- A. Construction and control joints indicated on Drawings are mandatory and shall not be omitted.
- B. Joints not indicated or specified shall be placed to least impair strength of structure and shall be subject to approval of Engineer.
- C. Waterstops:
  - 1. Protect waterstop from oil, dirt, concrete spatter, and damage, and leave clean to receive concrete forms. Exercise care during installation of waterstop to eliminate all possibilities that may cause leakage. Ensure reinforcing bars and slip dowels will not interfere with positioning of waterstop during Installation.
  - 2. Install waterstops in accordance with manufacturer's recommendations and as indicated. Hold waterstops rigidly in place by extending through slots in keyways, by spilt bulkheads, by tying to reinforcing bars, or by such other adequate methods as are

necessary to insure proper support and embedment during the concreting process. Secure waterstop between the last rib and the end of the waterstop when tying to reinforcing rods. Tie waterstop to reinforcing bars every 12 inches.

3. Install waterstop so that half of the ribs of the waterstop material are embedded in the concrete on each side of the joint. When installed in an expansion joint, exercise care in pouring so that the closed hollow center-bulb remains in the gap between the first and second pour, to allow for maximum elongation with minimum stress on the portion of the waterstop embedded in the concrete.
4. Install expansion joint material and a sealant in the joint, as indicated, to prevent foreign matter from accumulating in the joint area. When a sealant is used place a separator between the sealant and the waterstop to insure that both the waterstop and sealant best perform their respective functions.
5. Sweep horizontal joints prior to pour to insure that foreign matter does not interfere with direct contact between the waterstop and concrete.
6. Systematically and thoroughly vibrate concrete around waterstop to avoid honeycombs and voids in the concrete and to insure complete contact of waterstop to concrete.
7. For the second pour on horizontal sections, make a grout pour over the waterstop to prevent excessive movement of the waterstop and to provide positive insurance against honeycombing or voids. Use a thicker waterstop. 3/8 inch or 1/2 inch. for heavy pour or larger aggregate.
8. Where using split-ribbed waterstop spread open the split leg of the waterstop and nail it to the bulkhead between the last two ribs. Upon completion of the first pour and removal of the bulkhead, join the split leg together every 12 inches with hog rings and position it for the second pour.
9. PVC waterstop may be butt-spliced on the job with an electrical splicing iron or a hot air welding gun and vinyl welding rod in accordance with the manufacturer's instructions.
10. Do not drive nails through center of waterstop. Do not lap waterstop, splice joints. Do not embed center bulb in concrete. Position it in the center of the joint to insure freedom of movement. Do not secure waterstop except between the last rib and the end of the waterstop when tying to the reinforcing rod to hold in place for the pour. Where using split-ribbed waterstop, do not nail split legs to bulkhead adjacent to bulb.

### **3.6 INSTALLATION OF EMBEDDED ITEMS**

- A. Conform to requirements of ACI 318, paragraph 6.3, "Conduits and Pipes Embedded in Concrete", and as specified below.
- B. Install steel sleeves, embedded wall plates and similar items, furnished by other trades, at locations shown on the drawings.
- C. Anchor bolts for column baseplates shall be installed with templates provided. Vertical alignment and plan locations shall be maintained within one-sixteenth inches of the locations shown on the drawings.
  1. Inspection shall be performed by a surveyor licensed in the Commonwealth of Massachusetts. Certify compliance with shop drawings.

### **3.7 MIXING, CONSISTENCY, AND DELIVERY OF CONCRETE**

- A. Concrete shall be ready-mixed, produced by plant acceptable to Engineer. Hand or site mixing shall not be done. Constituents, including admixtures except certain corrosion inhibitors and superplasticizers, shall be batched at central batch plant. Admixtures shall be premixed in solution form and dispensed as recommended by manufacturer.
- B. Central plant and rolling stock equipment and methods shall conform with Truck Mixer and Agitator Standard of Truck Mixer Manufacturer's Bureau of National Ready-Mixed Concrete Association, and Contract Documents. Consistency of concrete at time of deposit shall be as per section 2.2F.:
- C. Ready mixed concrete shall be transported to site in watertight agitator or mixer trucks loaded not in excess of rated capacities. Discharge at site shall be within one and one-half hours after cement was first introduced into mix. Discard concrete not discharged within one and one-half hours and dispose of legally. Concrete with a temperature greater than 85 degrees F. shall not be placed. Central mixed concrete shall be plant mixed a minimum of five minutes. Agitation shall begin immediately after premixed concrete is placed in truck and shall continue without interruption until discharged. Transit mixed concrete shall be mixed at mixing speed for at least ten minutes immediately after charging truck followed by agitation without interruption until discharged. Concrete shall be furnished by a single plant unless accepted by the Engineer in writing.
- D. Retempering of concrete which has partially hardened, that is, mixing with or without additional cement, aggregates, or water, will not be permitted.

### **3.8 PLACING CONCRETE**

- A. Remove water and foreign matter from forms and excavations and, except in freezing weather or as otherwise directed, thoroughly wet wood forms just prior to placing concrete. Place no concrete on frozen soil and provide adequate protection against frost action during freezing weather.
- B. To secure full bond at construction joints, surfaces of concrete already placed, including vertical and inclined surfaces, shall be thoroughly cleaned of foreign materials and laitance, roughened with suitable tools such as chipping hammers or wire brushes, and recleaned by stream of water or compressed air. Well before new concrete is deposited, joints shall be saturated with water. After free or glistening water disappears joints shall be given thorough coating of neat cement slurry mixed to consistency of very heavy paste. Surface shall receive coating of approximately one-eighth inch thick; this shall be scrubbed in by means of stiff bristle brushes. New concrete shall be deposited before neat cement dries or changes color.
- C. Do not place concrete having slump outside of allowable slump range.
- D. Transport concrete from mixer to place of final deposit as rapidly as practical by methods which prevent separation of ingredients and displacement of reinforcement, and which avoid rehandling. Deposit no partially hardened concrete. When concrete is conveyed by chutes, equipment shall be of such size and U-shaped design as to insure continuous flow in chute. Flat (coal) chutes shall not be employed. Chutes shall be of metal or metal lined and different



portions shall have approximately same slope. Slope shall not be less than 25 degrees nor more than 45 degrees from horizontal and shall be such as to prevent segregation of ingredients. Discharge end of chute shall be provided with baffle plate or spout to prevent segregation. If discharge end of chute is more than five feet above surface of concrete in forms, spout shall be used, and lower and maintained as near surface of deposit as practicable. When operation is intermittent, chute shall discharge into hopper. Chute shall be thoroughly cleaned before and after each run and debris and any water used shall be discharged outside forms. Concrete shall not be allowed to flow horizontally over distances exceeding five feet.

- E. Concrete shall be placed in such manner as to prevent segregation, and accumulations of hardened concrete on forms or reinforcement above mass of concrete being placed. To achieve this end, suitable hoppers, spouts with restricted outlets and tremies shall be used as required.
- F. During and immediately after depositing, concrete shall be thoroughly compacted by means of internal type mechanical vibrators or other tools, or by spading to produce required quality of finish. Vibration shall be done by experienced operators under close supervision and shall be carried on only enough to produce homogeneity and optimum consolidation without permitting segregation of constituents or "pumping" of air. Vibrators used for normal weight concrete shall operate at speed at not less than 7,000 vpm and be of suitable capacity. Do not use vibrators to move concrete. Vibration shall be supplemented by proper wooden spade puddling to remove included bubbles and honeycomb adjacent to visible surfaces. At least one vibrator shall be on hand for every 10 cubic yards of concrete placed per hour, plus one spare. Vibrators shall be operable and on site prior to starting placement.
- G. Vertical lifts shall not exceed 18 inches. Vibrate completely through successive lifts to avoid pour lines. Vibrate first lift thoroughly until top of lift glistens to avoid stone pockets, honeycomb, and segregation.
- H. Concrete shall be deposited continuously, and in layers of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause formation of seams and planes of weakness within section. If section cannot be placed continuously between planned construction joints, as specified, field joint and additional reinforcement shall be introduced so as to preserve structural continuity. Engineer shall be notified in any such case.
- I. Cold joints, particularly in exposed concrete, including "honeycomb", are unacceptable. If they occur in concrete surfaces exposed to view, Engineer will require that entire section in which blemish occurs be removed and replaced with new materials at Contractor's expense.
- J. When placing exposed concrete walls or columns, strike corners of forms rapidly and repeatedly from outside along full height while depositing concrete and vibrating.
- K. Chutes, hoppers, spouts, adjacent work, etc. shall be thoroughly cleaned before and after each run and water and debris shall be discharged outside form.

### **3.9 FINISHING OF UNFORMED CONCRETE SURFACES (ALL SURFACES OF CANOPY)**

- A. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Remove fins and other projections exceeding specified limits on formed-surface irregularities.
  - 1. In Addition, provide Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.

### **3.10 FINISHING OF UNFORMED CONCRETE SURFACES**

- A. Smooth troweled finish: Shall be provided where concrete flatwork is to be exposed in the finished work or is to receive resilient flooring materials.
- B. Floated finish: Shall be provided where concrete flatwork is to receive waterproofing membranes or setting beds for finished materials.
- C. Floated finish: Shall be provided for top surfaces of walls, slabs and beams.
- D. Rough struck surface shall be provided at top of pedestals.
- E. Steel Broom Finish (with smooth edging): Shall be provided at exterior concrete walks, pavements and steps.
- F. Contractor, at his own expense, shall level depressed spots and grind high spots in concrete surfaces which are in excess of specified tolerances. Leveling materials proposed for providing proper surface shall be approved by Engineer.

### **3.11 REPAIRING OF UNFORMED CONCRETE SURFACES**

- A. Tops of slabs and walls shall be repaired by using either same material as originally cast or by use of dry-pack material, as approved by Engineer. Areas affected shall be chipped back square and to depth of one inch minimum. Hole shall then be moistened with water for a minimum of two hours, followed by brush coat of 1/16 inch thick cement paste. Immediately plug hole with concrete, or with dry pack material consisting of 1:1.5 mixture of cement and concrete sand mixed slightly damp to touch. Hammer dry-pack into hole until dense, and excess paste appears on surface. Finish patch flush and to same texture as surrounding concrete. For large repairs employ 1-1-2 mixture of cement, concrete sand and pea gravel at same dry-pack consistency.

### **3.12 CURING, SEALING AND PROTECTION**

- A. When concrete is placed at or below ambient air temperatures of 40 degrees F. or whenever in opinion of Engineer, such or lower temperatures are likely to occur within 48 hours after placement of concrete, cold weather concreting procedures, according to ACI 306 and as specified herein, shall be followed. To this end, entire area affected shall be protected by

adequate housing or covering, and heating. No salt, chemicals or other foreign materials shall be used in the mix to lower freezing point of concrete.

- B. Protect concrete work against injury from heat, cold, and defacement of any nature during construction operations.
- C. Concrete shall be treated and protected immediately after concreting or cement finishing is completed, to provide continuous moist curing above 50 degrees F. for at least seven days, regardless of ambient air temperatures.
- D. Curing compounds will not be permitted for slab and beams.
- E. Keep permanent temperature record showing date and outside temperature for concreting operations. Thermometer readings shall be taken at start of work in morning, at noon, and again late in afternoon. Locations of concrete placed during such periods shall likewise be recorded, in such manner as to show any effect temperatures may have had on construction. Copies of temperature record shall be distributed daily to Engineer.
- F. Epoxy Curing Compounds/Hardener:
  - 1. Apply the first coat of epoxy to the plastic concrete as soon as the bleed water has totally disappeared. This application shall serve a dual function: a membrane curing compound which shall retain 95% or more of the mixing water in the concrete for a minimum of seven days; and the first coat of a two-coat system to seal and protect the concrete.
  - 2. After a minimum curing period of 30 days and before the structure is opened to general use, wash the concrete with cleaning and degreasing chemical solution applied in accordance with the manufacturer's instructions and as specified herein.
  - 3. Prepare the cleaning solution in accordance with the manufacturer's instructions. Dampen concrete surface with water. Apply the prepared solution over the area to be cleaned using a soft fibered but densely filled brush. Allow the solution to remain on the surface for 3 to 5 minutes. Reapply the cleaning solution and scrub vigorously. Rinse with fresh water applied at a pressure of 400-800 psi and a volume of water per minute 5 - 10 gallons. Protect all non-masonry surfaces.
  - 4. Allow concrete to dry a minimum of 24 hours and a maximum of 48 hours before application of the second coat of epoxy.
  - 5. Pour equal quantities of Components 'A' and 'B' into a clean container. Mix thoroughly with a low speed electric drill equipped with a steel paddle. Keep individual components and mixed compound covered when material is not being used.
  - 6. Application: Apply mixed epoxy compound in a uniform coat at the rate of approximately 200 sq. ft. per gallon. Mixed material may be sprayed with any equipment capable of spraying epoxy compounds, or it may be applied with a deep nap lamb's wool roller.
  - 7. Protect surface against vehicular and pedestrian traffic during curing period (24 hours at 75°F).
  - 8. Final Coat - Broom Finish and Wood Float Finish: Concrete is totally sealed against contaminants and resists the attack of de-icing chemicals. It may be applied at any time after the concrete has cured a minimum of 30 days and before the structure is opened to general use. Apply the epoxy compound by spray or roller at the rate of 275 to 325 sq. ft. per gallon being careful to avoid puddles or uneven application. The concrete shall exhibit a uniform gloss indicating it is totally sealed. Any areas that are dull or flat are

not totally sealed. Any areas that are dull or flat are not totally sealed and shall be given a third coat.

9. Final Coat - Steel Trowel Finish Concrete: Apply the second and final coat at any time after the concrete has cured a minimum of 30 days and before the structure is opened to general use. Apply mixed epoxy compound in a uniform coat at a rate not to exceed 200 sq. ft. per gallon. While the epoxy compound is still liquid, drop fine sand meeting the gradation requirements of ASTM C-109, vertically into the epoxy at a uniform rate of one lb. per sq. ft. Make sure entire epoxy surface is thoroughly covered. After epoxy has hardened so that it cannot be dented with a screwdriver, remove excess sand.

- G. Concrete Sealer: Apply to bridge copings, beam sets, parapets, vehicle barriers, boatwalls portal flank walls and other concrete surfaces indicated. Apply in accordance with manufacturer's instructions and the following:

1. Application of the sealer shall not alter the surface texture and shall be compatible with the use of surface finish coatings and caulking. Surface shall dry to a tack-free condition in 4 hours or less.
2. Preparation process shall not cause any undue damage to the concrete surface, remove or alter the existing surface finish, or expose the coarse aggregate of the concrete.
3. Concrete sealer shall be used as supplied by the manufacturer and not altered in any way. Apply onto concrete surfaces at manufacturer's recommended rate of coverage.
4. Prevent the concrete sealer from coming in contact with open joints that have not yet been filled with joint sealant, so as to prevent any loss of bond of the joint sealant.

### 3.13 REMOVAL OF FORMWORK, SHORING AND RESHORING

- A. Contractor shall be responsible for proper removal of formwork, shoring, and reshoring.
- B. Forms shall be removed only after concrete has attained sufficient strength to support its own weight, construction loads to be placed thereon and lateral loads, without damage to structure or excessive deflection.
- C. Forms and falsework shall not be removed unless the concrete has attained the minimum percentage compressive strength as listed in the following table:

<u>Structural Member</u>	<u>Minimum Percent of Design Strength (f'c)</u>
1. Invert Slabs; Slabs and Beams on Grade	25
2. Free Standing Walls, Columns and Piers	40
3. Retaining Walls	50
4. Soffits of Beams, Slabs and Girders Less Than 20 Foot Span	80
5. Stairs	80
6. Soffits of Beams, Slabs and Girders Greater Than 20 Foot Span	90
7. Cantilevered Beams, Slabs and Girders	90

- D. Acceptance for form removal will be based on field-cured concrete cylinders tested by the MBTA Lab.

### 3.14 REPAIRING AND FINISHING OF FORMED AND ARCHITECTURAL CONCRETE SURFACES

- A. In accordance with the provisions of ACI 301, Chapter 10, all concrete shall have "smooth form finish".
- B. Intent of this Specification is to require forms, mixtures of concrete, and workmanship so that concrete surfaces will require no patching, except for plugging of tie holes. However, where patching is acceptable to Engineer, procedure described below shall be followed.
- C. Defective concrete and honeycombed areas shall not be patched unless examined and approval is given by Engineer. If such approval is received by Contractor, areas involved shall be chipped down square and at least one inch deep to sound concrete by means of cold chisels or pneumatic chipping hammers. If honeycomb exists around reinforcement, chip to provide clear space at least three-quarter inch wide all around steel to afford proper ultimate bond thereto. For areas less than one and one-half inches deep, patch shall be made in same manner as described above for filling unformed concrete surfaces, care being exercised to use crumbly-dry (nontrowelable) mixtures and to avoid sagging. Thicker repairs shall require build-up in successive days, each layer being applied as described. To aid strength and bonding of multiple layer repairs, non-shrink, non-metallic aggregate shall be used as an additive as follows:

Materials	Volumes	Weights
Cement	1.0	1.0
Non-Metallic Aggregate	0.15	0.25
Sand	1.5	1.55

1. For very heavy (generally, formed) patches, pea gravel may be added to mixture and proportions modified as follows:

Materials	Volumes	Weights
Cement	1.0	1.0
Non-Metallic Aggregate	0.2	0.33
Sand	1.0	1.0
Pea Gravel	1.5	1.55

- D. After hardening, rub lightly as described above for form tie holes.
1. Mortar for patching shall be same mix as above except aggregate shall pass a No. 14 sieve.
  2. For all concrete to receive "smooth" finish, remove formwork fins and clean entire surface of grease, form oil, laitance, dust, and other foreign matter.
  3. "Smooth" finish shall consist of having all fins removed, joint marks smoothed off, blemishes removed, and surfaces left smooth and unmarred.
  4. Begin finishing operations as soon as practicable after removal of forms, continue with curing operations after finishing is completed. After concrete has been well cured, carefully inspect surfaces. Remove any fins, rough spots, streaks, hardened mortar or grout and other foreign material. Patch defects with finishing mortar as specified above, to satisfaction of Engineer.

- E. Patches which become crazed, cracked, or sound hollow upon tapping shall be removed and replaced with new material at Contractor's expense.

### **3.15 CLEANING**

- A. Concrete surfaces shall be cleaned of objectionable stains as determined by the Engineer. Materials containing acid in any form or methods which will damage "skin" of concrete surfaces shall not be employed, except where otherwise specified.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of the Cast-in-Place Concrete for the BRT Stations.

## **END OF SECTION**

## **SECTION 05041**

### **HOT-DIP GALVANIZING**

#### **PART 1 - GENERAL**

##### **1.1 DESCRIPTION**

- A. This Section specifies Hot-Dip Galvanizing for all miscellaneous steel, architecturally exposed steel, and structural steel that is exposed to view, the weather, moisture, or corrosive atmosphere.
- B. Definition of Hot-Dip Galvanizing: The dipping of steel members and assemblies into an alloy of molten zinc and nickel for lasting long-term protection. The resultant nickel zinc alloys with the base metal.

##### **1.2 RELATED WORK**

- A. Carefully examine all of the Contract Documents for requirements which affect the work of this section.
- B. Other specification sections which directly relate to the work of this section include, but are not limited to, the following:
  - 1. Section 05100 - STRUCTURAL STEEL
  - 2. Section 05500 - MISCELLANEOUS METALS
  - 3. Section 07600 - FLASHING AND SHEET METAL
  - 4. Section 10420 – FIXED SIGNAGE

##### **1.3 QUALITY ASSURANCE**

- A. Reference Standard:
  - 1. American Hot-Dip Galvanizers Association, Inc., (AHDGA):  
Publication entitled “Inspection Manual for Hot-Dip Galvanized Products.
  - 2. American Society for Testing and Materials (ASTM):
    - A 123 – Zinc Coating (Hot-Dip) on Iron and Steel Hardware
    - A 143 – Safeguarding Against Embrittlement
    - A 384 – Safeguarding Against Warpage
    - A 385 – Providing High Quality Zinc Coatings
    - A 780 – Repair of Hot-Dip Galvanizing

##### **1.4 SUBMITTALS**

- A. Certification: Furnish Notarized Certificates of Compliance with ASTM Standards and Specifications herein listed. Each Certificate to be signed by the Galvanizer and shall list a detailed description of all material. Certification shall state that the galvanizing is in full conformance with these specifications.
- B. Visual Stamp: Mark all lots of material with a clearly visible tag indicating the name of the galvanizer, the weight of the nickel – the coating and the applicable ASTM Specification numbers.
- C. Product Data: Submit product literature and sample for organic zinc rich repair compounds to be used.

## **1.5 PRODUCT DELIVERY, STORAGE AND HANDLING**

- A. Packaging: Of a suitable type to prevent damage to the finished surface and to prevent shipping damage to the material.
- B. Handling and Storage: Handle and Store in such a manner as to minimize damage to the finished material.

## **PRODUCTS**

### **1.6 STEEL MATERIALS**

- A. Material for galvanizing shall be geometrically suitable for galvanizing as specified in ASTM A-384 and A-385.
- B. To be chemically suitable for galvanizing, steel shall contain carbon below 0.25%; phosphorous below 0.05%; manganese below 1.35%.

### **1.7 NICKEL-ZINC FOR GALVANIZING**

- A. Conform to ASTM B-6, as specified in ASTM A123 only with the addition to the bath of a predetermined amount of nickel (not less than 0.05% by weight) to counter the affect of high silicon steel.

### **1.8 GALVANIZING**

- A. Steel members, fabrications, and assemblies as identified in Section 1.01A shall be galvanized after fabrication in accordance with ASTM A123.
- B. Safeguard against embrittlement in conformance with ASTM A143.
- C. To safeguard against warpage or distortion of steel members, in conformance with ASTM A384, submit shop drawings of non-standard fabrications, all tubular fabrications, all fabrications involving materials of different thicknesses. Submit drawings to the galvanizer prior to fabrication to determine the suitability of the material for galvanizing.



1. Note on shop drawings locations of “blow holes” so that they can be drilled prior to galvanizing.
- D. Weight of Coating: Weight of all zinc coating shall be 2.0 ounces per sq. ft. minimum.
- E. Galvanizing Application: Galvanize materials in accordance with specified standards and this Specification. Galvanizing shall provide an acceptable substrate for applied coatings. After pickling and prior to galvanizing, the steel shall be immersed in a bath of zinc ammonium chloride. The dry kettle process shall be used to eliminate any flux inclusions on the surface of the galvanized material.
- F. Galvanizing shall be performed under conditions so that “White Rust” is avoided.
- G. Fabricator shall “dry-erect” canopies, stairs, and bench windcreens prior to galvanizing, to ensure proper fit.

## **PART 2 - EXECUTION**

### **2.1 INSTALLATION OF STEEL MATERIALS**

- A. Steel materials, fabrications, and assemblies are specified to be installed in various other sections under Division 05, METALS.

### **2.2 TOUCH-UP AND REPAIR**

- A. Repair damaged and field welded galvanized surface in accordance with ASTM A780.
- B. Dry film thickness of the organic zinc rich repair compound shall not be less than 6 mils.

## **PART 3 - MEASUREMENT AND PAYMENT**

### **3.1 GENERAL**

- A. Separate measurement and payment will not be made for all work required under this Section, but all costs in connection therefore will be considered incidental to the item of work to which it pertains.

## **END OF SECTION**

**SECTION 05100**  
**STRUCTURAL STEEL**

**PART 1 - GENERAL**

**1.1 DESCRIPTION OF WORK**

- A. Work Included: This Section specifies structural steel for canopy/roofing structures, steel piles for soldier pile excavation support, and support frames for prefabricated buildings and shelters.
- B. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
  - 1. Section 05041 – HOT-DIP GALVANIZING
  - 2. Section 05500 – MISCELLANEOUS METAL

**1.2 DEFINITION**

- A. Structural Steel: Elements of structural-steel frame, as classified by AISC's "Code of Standard Practice for Steel Buildings and Bridges", that support design loads.

**1.3 PERFORMANCE REQUIREMENTS**

- A. Connections: Provide details of connections required by the Contract Documents to be selected or completed by the structural-steel fabricator to withstand loads indicated and comply with other information and restrictions indicated.
  - 1. Select and complete connections using the American Institute of Steel Construction's (AISC) "Manual of Steel Construction, Load and Resistance Factor Design", Volume 2, Part 9.
  - 2. Engineering Responsibility: Fabricator's responsibilities include using a qualified professional engineer to prepare structural analysis and design of structural-steel connections for structures, canopy structures, bench structures, and sign support structures.

**1.4 SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Show fabrication of structural-steel components.
  - 1. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
  - 2. Include embedment drawings.
  - 3. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length and type of each weld.

4. Indicate type, size and length of bolts, distinguishing between shop and field bolts. Identify pre-tensioned and slip-critical high-strength bolted connections.
  5. For structural-steel connections indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- C. Welding Certificates: Certificate from AWS indicating certification in type of welding required for each welder and welding operator.
- D. Welding Records and Data:
1. Before welding, submit the procedure which will be used for qualifying welders and welding procedures. For procedures other than those pre-qualified in accordance with AWS D1.1, submit a copy of procedure qualification test records.
  2. Submit certified copy of qualification test records for each welder, welding operator, and tacker who will be employed in the work.
  3. If field welding is permitted, submit descriptive data for field welding equipment.
  4. Submit all NDE records (radiographs, ultrasonic, magnetic particle) and visual inspection reports upon completion or when otherwise requested by the Engineer.
- E. Qualification Data: For installer, fabricator, professional engineer, testing agency, welding inspectors, NDE inspectors and galvanizer. Submit prior to starting work.
- F. Mill Test Reports: Signed by manufacturers certifying that the following products comply with requirements:
1. Structural steel including chemical and physical properties.
  2. Bolts, nuts, and washers including mechanical properties and chemical analysis.
  3. Direct-tension indicators.
  4. Tension-control, high-strength bolt-nut-washer assemblies.
  5. Shear stud connectors.
  6. Nonshrink grout.

## **1.5 QUALITY ASSURANCE**

- A. Fabricator Qualifications: A qualified fabricator who participates in the AISC Quality Certification Program and is certified for: Steel Building Structures (STD); or Simple Steel Bridge Structures (SBD); or Major Steel Bridges (CBR) as applicable
- B. Galvanizer Qualifications: Engage the services of a qualified galvanizer who has demonstrated a minimum of five years experience in the successful application of galvanized coatings specified in this Section in the facility where the work is to be performed and who will apply the coatings within the same facility.
- C. Installer Qualifications: A qualified installer with previous experience in installing structural steel.

- D. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel"
- E. Comply with applicable provisions of the following specifications and documents:
1. AISC's "Code of Standard Practice for Steel Buildings and Bridges"
  2. AISC's "Seismic Provisions for Structural Steel Buildings" and "Supplement No. 2"
  3. AISC's "Specification for Structural Steel Buildings--Allowable Stress Design and Plastic Design" and "Load and Resistance Factor Design Specification for Structural Steel Buildings"
  4. AISC's "Specification for the Design of Steel Hollow Structural Sections"
  5. AISC's "Specification for Allowable Stress Design of Single-Angle Members" and "Specification for Load and Resistance Factor Design of Single-Angle Members"
  6. RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts"
- F. Tests and Inspection
1. The Contractor will test and inspect high-strength bolted connections and welded connections and prepare test reports. Specialty tests shall be performed at no expense to the Authority by an independent testing laboratory approved by the Engineer. Costs of specialty tests shall be borne by the Contractor. Test reports shall be submitted to the Engineer for approval.
  2. The Engineer reserves the right to inspect high-strength bolted connections and weld connections. Provide access to places where structural steel work is being fabricated or erected so that required inspection and testing can be accomplished at no change in Contract Price. At times, inspection may require moving or handling of steel to permit proper inspection. Notify Materials Testing Laboratory not less than 48 hours prior to start of fabrication.
  3. The Engineer may inspect structural steel at the plant before shipment; however, the Engineer reserves the right, at any time before final acceptance, to reject material not complying with specified requirements.
  4. Correct deficiencies in structural steel work that inspections and laboratory test reports have indicated to be not in compliance with requirements at the Contractor's expense. Perform additional tests, at no expense to the Authority, as may be necessary to reconfirm any non-compliance of the original work, and as may be necessary to show compliance of corrected work.
  5. Specialty Tests: Nondestructive examination of welds in accordance with provisions of AWS D1.1 and ASTM Standards noted shall be made in accordance with the following schedule:
    - a. Radiographic Examination of Welds, per ASTM E94 and E142:
      - 1) Field, complete joint penetration groove welds:
        - a) 1 out of 5 (20 percent) with thickness equal to or less than 3/4 inch.
        - b) 100 percent with thickness greater than 3/4 inch.
      - 2) Shop, complete joint penetration groove welds:
        - a) 1 out of 10 (10 percent) with thickness equal to or less than 3/4 inch.

- b) 1 out of 2 (50 percent) with thickness greater than 3/4 inch and equal to or less than 1-1/2 inches.
      - c) 100 percent for thickness greater than 1-1/2 inches.
    - b. Ultrasonic Examination, per ASTM E164: Complete joint penetration groove butt welds not accessible for radiographic examination shall be subjected to ultrasonic testing. The extent shall be the same as noted for radiographic examination. Ultrasonic examination shall be made 48 to 72 hours after welding at locations on weldments or welded joints subject to high restraint as indicated in order to check for lamellar tearing. The exact location of the areas to be inspected shall be determined with the Engineer at the time of fabrication. This examination shall be made according to the following schedule unless conditions of tearing require a greater number of tests, as directed:
      - 1) 1 out of 10 (10 percent) for thickness equal to or less than 3/4 inch.
      - 2) 1 out of 5 (20 percent) for thickness greater than 3/4 inch and equal to or less than 1-1/4 inches.
      - 3) 1 out of 2 (50 percent) for thickness greater than 1-1/4 inches.
    - c. Magnetic Particle Examination, per ASTM E709, field and shop:
      - 1) 1 out of 5 (20 percent) of complete joint penetration groove welds of tee and corner joints.
      - 2) 1 out of 10 (10 percent) of partial joint penetration groove and fillet welds.
    - d. Penetrant Examination, per ASTM E165: Shall be used for detecting discontinuities that are open to the surface use as appropriate.
  - 6. Visual Examination: All welds whether otherwise examined or not shall be visually examined and faulty joints shall be marked for correction.
  - 7. When any testing, examination or inspection reveals faulty welds, all joints of the same type shall be checked at no expense to the Authority until the integrity of the weld is assured before resuming examination.
  - 8. After faulty welds have been corrected or repaired, they shall each be re-examined at no expense to the Authority in the manner specified for the original joint.
  - 9. It is intended that inspections shall be performed to permit an orderly flow of completed material from the shop. Work with the Engineer to establish a schedule that will permit this.
  - 10. Test result information shall be forwarded to the Engineer immediately after test results are available stating the acceptance or rejection of fabricated pieces in order that the repairs and re-inspection may be made as soon as possible.
- G. Pre-Installation Conference: Contractor shall schedule a meeting to be attended by Contractor, Engineer, fabricator and galvanizer. Agenda shall include the following: Project schedule, source for each fabrication, coordination between fabricator and galvanizer and adjacent Work, finish of surfaces, application of coatings, submittals, and approvals.

## **1.6 DELIVERY, STORAGE, AND HANDLING**

- A. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from erosion and deterioration.
  - 1. Store fasteners in a protected place. Clean and re-lubricate bolts and nuts that become dry or rusty before use.
  - 2. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.

## **1.7 COORDINATION**

- A. Furnish anchorage items to be embedded in or attached to other construction without delaying the Work. Provide setting diagrams, sheet metal templates, instructions and directions for installation.

# **PART 2 - PRODUCTS**

## **2.1 STRUCTURAL-STEEL MATERIALS**

- A. Channels, Angles, M-Shapes, S-Shapes, W-Shapes: ASTM A 572 or A 709, Grade 50 or as indicated on the Plans.
  - 1. Finish: Hot-dip zinc coating, ASTM A 153, Class C (except for soldier piles completely faced with concrete).
- B. Plate and Bar: ASTM A 572/A 572M, Grade 50.
  - 1. Finish: Hot-dip zinc coating, ASTM A 153, Class C.
- C. Cold-Formed Hollow Structural Sections: ASTM A 500, Grade B, structural tubing.
  - 1. Finish: Hot-dip zinc coating, ASTM A 153, Class C.
- D. Steel Pipe: ASTM A 53, Type E or S, Grade B.
  - 1. Finish: Hot-dip zinc coating, ASTM A 153, Class C.
- E. Medium-Strength Steel Castings: ASTM A 27, Grade 65-35 carbon steel.
  - 1. Finish: Hot-dip zinc coating, ASTM A 153, Class C.
- F. High-Strength Steel Castings: ASTM A 148, Grade 80-50, carbon or alloy steel.
- G. Welding Electrodes: Comply with AWS requirements.

## **2.2 BOLTS, CONNECTORS, AND ANCHORS**

- A. High-Strength Bolts, Nuts, and Washers: ASTM A 325, Type 1, heavy hex steel structural bolts; ASTM A 563 heavy hex carbon-steel nuts; and ASTM F 436 hardened carbon-steel washers.
  - 1. Finish: Hot-dip zinc coating, ASTM A 153, Class C.
- B. Tension-Control, High-Strength Bolt-Nut-Washer Assemblies: ASTM F 1852, Type 1, steel structural bolts with splined ends; ASTM A 563 heavy hex carbon-steel nuts; and ASTM F 436 hardened carbon-steel washers. Finish, mechanically deposited zinc coating, ASTM B 695, Class 50.
- C. Shear Connectors: ASTM A 307, Grade 50, headed-stud type, cold-finished carbon steel; AWS D1.1, Type B.
- D. Anchor Rods: ASTM F 1554, grade 105, hot-dip zinc coating, ASTM A 153, Class C.
- E. Threaded Rods: ASTM A 193, grade as applicable, hot-dip zinc coating, ASTM A 153, Class C.
- F. Eye Bolts and Nuts: ASTM A 108, Grade 1030, cold-finished carbon steel.
- G. Sleeve Nuts: ASTM A 108, Grade 1018, cold-finished carbon steel.

## **2.3 MISCELLANEOUS MATERIALS**

- A. Galvanizing Repair Paint: Coatings meeting requirements of ASTM A 780.
- B. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

## **2.4 FABRICATION**

- A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate according to AISC's "Code of Standard Practice for Steel Buildings and Bridges" and AISC's "Specification for Structural Steel Buildings--Allowable Stress Design and Plastic Design".
  - 1. Camber structural-steel members where indicated.
  - 2. Identify high-strength structural steel according to ASTM A 6/ A 6M and maintain markings until structural steel has been erected.
  - 3. Mark and match-mark materials for field assembly.
  - 4. Complete structural-steel assemblies, including welding of units, before starting shop-priming operations.
- B. Thermal Cutting: Perform thermal cutting by machine to greatest extent possible. Plane thermally cut edges to be welded to comply with requirements in AWS D1.1.

- C. Bolt Holes: All bolt holes shall be drilled perpendicular to metal surfaces.
- D. Finishing: Accurately finish ends of columns and other members transmitting bearing loads.
- E. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1 and manufacturer's written instructions.
- F. Holes: Provide holes required for securing other work to structural steel and for passage of other work through steel framing members.
  - 1. Drill holes perpendicular to steel surfaces. Do not thermally cut bolt holes or enlarge holes by burning.
  - 2. Base-Plate Holes: Drill holes perpendicular to steel surfaces.
  - 3. Weld threaded nuts to framing and other specialty items indicated to receive other work.

## **2.5 SHOP CONNECTIONS**

- A. High-Strength Bolts: Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.
- B. Weld Connections: Comply with AWS D1.1 for welding procedure specifications, tolerances, appearance, and quality of welds and for methods used in correcting welding work. Complete welds in accordance with the Contract Drawings.
  - 1. Remove backing bars or runoff tabs, back gouge, and grind steel smooth.
  - 2. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances of AISC's "Code of Standard Practice for Steel Buildings and Bridges" for mill material.
  - 3. Insufficient welds shall be rejected and corrected until required profiles are met.
  - 4. Verify that weld sizes, fabrication sequence, and equipment used for architecturally exposed structural steel will limit distortions to allowable tolerances. Prevent weld show-through on exposed steel surfaces.
    - a. Grind butt welds flush.
    - b. Grind or fill exposed fillet welds to smooth profile. Dress exposed welds.
  - 5. No skip welds will be permitted for steel connections to be coated.

## **2.6 STEEL FINISHES**

- A. All structural steel and connections shall be hot-dipped galvanized unless otherwise noted in the Contract Plans. Hot-Dip Galvanizing shall be performed in accordance with Section 05041 – Hot Dip Galvanizing.



## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Verify elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments, with steel erector present, for compliance with requirements. Elevations shall be verified by a surveyor licensed in the Commonwealth of Massachusetts.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 PREPARATION**

- A. Provide temporary shores, guys, braces, and other supports during erection to keep structural steel secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place, unless otherwise indicated. Do not remove temporary shoring supporting composite deck construction until cast-in-place concrete has attained its design compressive strength.

### **3.3 ERECTION**

- A. Set structural steel accurately in locations and to elevations indicated and according to AISC's "Code of Standard Practice for Steel Buildings and Bridges".
- B. Base and Bearing Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting base and bearing plates. Clean bottom surface of base and bearing plates.
  - 1. Set base and bearing plates for structural members on wedges, shims, or setting nuts as required.
  - 2. Weld plate washers to top of base plate.
  - 3. Snug-tighten or pretension anchor rods as applicable after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of base or bearing plate before packing with grout.
  - 4. Promptly pack grout solidly between bearing surfaces and base or bearing plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.
- C. Maintain erection tolerances of structural steel and architecturally exposed structural steel within AISC's "Code of Standard Practice for Steel Buildings and Bridges".
- D. Align and adjust various members forming part of complete frame or structure before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that will be in permanent contact with members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.

1. Level and plumb individual members of structure.
  2. Make allowances for difference between temperature at time of erection and mean temperature when structure is completed and in service.
- E. Splice members only where indicated.
- F. Remove erection bolts on welded, architecturally exposed structural steel; fill holes with plug welds; and grind smooth at exposed surfaces.
- G. Do not use thermal cutting during erection unless approved by Engineer. Finish thermally cut sections within smoothness limits in AWS D1.1.
- H. Do not enlarge unfair holes in members by burning or using drift pins. Ream holes that must be enlarged to admit bolts.
- I. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1 and manufacturer's written instructions.

### **3.4 FIELD CONNECTIONS**

- A. High-Strength Bolts: Install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint indicated on the Drawings.
- B. Weld Connections: Comply with AWS D1.1 for welding procedure specifications, tolerances, appearance, and quality of welds and for methods used in correcting welding work.
1. Comply with AISC's "Code of Standard Practice for Steel Buildings and Bridges" for bearing, adequacy of temporary connections, alignment, and removal of paint on surfaces adjacent to field welds.
  2. Remove backing bars or runoff tabs, back gouge, and grind steel smooth.
  3. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances of AISC's "Code of Standard Practice for Steel Buildings and Bridges" for mill material.
  4. Verify that weld sizes, fabrication sequence, and equipment used for architecturally exposed structural steel will limit distortions to allowable tolerances. Prevent weld show-through on exposed steel surfaces.
    - a. Grind butt welds flush.
    - b. Grind or fill exposed fillet welds to smooth profile. Dress exposed welds.
    - c. Re-profile all steel surfaces (using needle guns or other profiling methods) that have been welded and ground smooth to assure proper adhesion of primers and topcoats.

### **3.5 FIELD QUALITY CONTROL**

- A. Testing Agency: Engage a qualified independent testing and inspecting agency to inspect field welds and high-strength bolted connections.
- B. Bolted Connections: Bolted connections will be inspected according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts". When using bolted connections prime with "slip critical class B" primer as specified in this Section. All surfaces of bolted or bearing connections may be primed. When welding, hold back primer a minimum of 2 inches each side of weld.
- C. Welded Connections: Field welds will be visually inspected according to AWS D1.1. In addition to visual inspection, specialty tests will be performed in accordance with AWS D1.1 and at the frequency stated in Article 1.5.F.5
- D. In addition to visual inspection, test and inspect field-welded shear connectors according to requirements in AWS D1.1 for stud welding and as follows:
  - 1. Perform bend tests if visual inspections reveal either a less-than- continuous 360-degree flash or welding repairs to any shear connector.
  - 2. Conduct tests on additional shear connectors if weld fracture occurs on shear connectors already tested, according to requirements in AWS D1.1.
- E. Correct deficiencies in Work that test reports and inspections indicate do not comply with the Contract Documents.

### **3.6 REPAIRS AND PROTECTION**

- A. Repair damaged galvanized coatings on galvanized items with galvanized repair paint according to ASTM A 780 and manufacturer's written instructions.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 MEASUREMENT**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of the Steel elements for the BRT Stations. .

## **END OF SECTION**

**SECTION 05500**  
**MISCELLANEOUS METALS**

**PART 1 - GENERAL**

**1.1 DESCRIPTION OF WORK**

- A. Work Included: This Section specifies the following items.
  - 1. All Work in this Section; refer to Schedule in Par. 2.1 and as indicated on the Drawings.
- B. Items To Be Furnished Only: Furnish the following items for installation by the designated Sections
  - 1. Section 03330 – CAST-IN-PLACE CONCRETE.
    - a. Lintels, sleeves, anchors, inserts, plates and similar items.
- C. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
  - 1. Section 05100 - STRUCTURAL STEEL; structural steel items.

**1.2 PERFORMANCE REQUIREMENTS**

- A. Structural Performance of Ladders: Provide ladders capable of withstanding the effects of loads and stresses within limits and under conditions specified in ANSI A14.3.
- B. Thermal Movements: Provide exterior metal fabrications that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
  - 1. Temperature Change (Range): 120 deg F ambient; 180 deg F material surfaces.

**1.3 SUBMITTALS**

- A. Product Data: For paint products.
- B. Samples: Two three by six inch samples of shop-applied finishes, in color selected.
- C. Shop Drawings: Show fabrication and installation details for metal fabrications.
  - 1. Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items.

2. Provide templates for anchors and bolts specified for installation under other Sections.
  3. For installed products indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer licensed in the Commonwealth of Massachusetts responsible for their preparation.
- D. Certificates: Welder and weld procedure qualifications.
- E. Qualifications for Inspection and Testing Agency and Contractor's professional engineer indicating registration in the Commonwealth of Massachusetts.
- F. Weld inspection reports.

#### **1.4 QUALITY ASSURANCE**

- A. Welding: Qualify procedures and personnel according to the following:
1. AWS D1.1, "Structural Welding Code--Steel".
  2. AWS D1.2, "Structural Welding Code--Aluminum".
  3. AWS D1.3, "Structural Welding Code--Sheet Steel".
  4. AWS D1.6, "Structural Welding Code--Stainless Steel".
- B. Metal Surfaces, General: Provide materials with smooth, flat surfaces, unless otherwise indicated. For metal fabrications exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.
- C. Galvanizer Qualifications: Engage the services of a qualified galvanizer who has demonstrated a minimum of five years experience in the successful application of galvanized coatings specified in this Section in the facility where the work is to be performed and who will apply the coatings within the same facility.
- D. Pre-Installation Conference: Contractor shall schedule a meeting to be attended by Contractor, Engineer, fabricator, and galvanizer prior to starting Work. Agenda shall include the following: Project schedule, source for each fabrication, coordination between fabricator and galvanizer and adjacent Work, finish of surfaces, application of coatings, submittals, and approvals.
- E. Inspection. Except as otherwise specified, only visual inspection of welds, materials, workmanship, finished products, and installation is required.

#### **1.5 PROJECT CONDITIONS**

- A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication and indicate measurements on Shop Drawings. Provide allowance for trimming and fitting at site.

#### **1.6 COORDINATION**

- A. Coordinate installation of anchorages for metal fabrications. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor

bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

- B. Coordinate installation of steel weld plates and angles for casting into concrete that are specified in this Section but required for work of another Section. Deliver such items to Project site in time for installation.

## **PART 2 - PRODUCTS**

### **2.1 SCHEDULE**

- A. Metal fabrications include, but are not limited to, the following. Requirements for materials and coatings/finishes which are included as part of the Work specified in this Section are listed with each item.

	ITEM	MATERIAL	COATING/FINISH
1.	Exterior Handrails and Railings	Steel	Galv. & factory finish
2.	Weld plates and angles	Steel	Galv. & factory finish
3.	Supports for canopies (angles)	Steel	Galv. & factory finish
4.	Pipe Guards	Steel	Galv. & factory finish
5.	Expanded metal sheet paneling	Steel	Galv. & factory finish
6.	Rain leaders & electrical conduits	Steel	Galv. & factory finish
7.	Sign frame systems, poster cases	Steel	Galv. & factory finish
8.	Housing for VMS signs	Steel	Galv. & factory finish
9.	Bus Shelter Frames	Aluminum	Fluoropolymer
10.	Canopy Louvers	Aluminum	Fluoropolymer
11.	Hoods at lights	Aluminum	Fluoropolymer
12.	Bike Shelters	Steel	Galv. & factory finish

### **2.2 FERROUS METALS**

- A. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
- B. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A 666, Type 316L
- C. Stainless-Steel Bars and Shapes: ASTM A 276, Type 316L
- D. Rolled-Steel Floor Plate: ASTM A 786/A 786M, rolled from plate complying with ASTM A 36/A 36M or ASTM A 283/A 283M, Grade C or D.
- E. Steel Tubing: ASTM A 500, cold-formed steel tubing.
- F. Steel Pipe: ASTM A 53/A 53M, standard weight (Schedule 40), unless another weight is indicated or required by structural loads.
- G. Slotted Channel Framing: Cold-formed metal channels with continuous slot complying with Metal Framing Manufacturers Association MFMA-3.

- H. Cast Iron: ASTM A 48/A 48M, Class 30, unless another class is indicated or required by structural loads.
- I. Woven wire fabric: 1" x 1" flat top weave of 0.12" diameter pre-galvanized carbon steel wire.

## **2.3 NONFERROUS METALS**

- A. Aluminum Plate and Sheet: ASTM B 209, Alloy 6061-T6.
- B. Aluminum Extrusions: ASTM B 221, Alloy 6063-T6.
- C. Aluminum-Alloy Rolled Tread Plate: ASTM B 632/B 632M, Alloy 6061-T6.
- D. Aluminum Castings: ASTM B 26/B 26M, Alloy 443.0-F.

## **2.4 FASTENERS**

- A. General: Unless otherwise indicated, provide Type 316 stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B 633, Class Fe/Zn 5, within exterior walls. Provide stainless-steel fasteners for fastening aluminum. Select fasteners for type, grade, and class required. Provide neoprene spacers at connections for dissimilar metals.
- B. Anchor Bolts: ASTM F 1554, Grade 36. Provide hot-dip or mechanically deposited, zinc-coated anchor bolts where item being fastened is indicated to be galvanized.
- C. Cast-in-Place Anchors in Concrete: Anchors shall be capable of sustaining, without failure, a load equal to four times the load imposed. Tests shall be as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency. Threaded or wedge type; galvanized ferrous castings, either ASTM A 47/A 47M malleable iron or ASTM A 27/A 27M cast steel. Provide bolts, washers, and shims as needed, hot-dip galvanized per ASTM A 153/A 153M.
- D. Expansion Anchors: Anchor bolt and sleeve assembly with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488. Tests shall be conducted by a qualified independent testing agency.
  - 1. Material for Anchors in Interior Locations: Carbon-steel components zinc-plated to comply with ASTM B 633, Class Fe/Zn 5.
  - 2. Material for Anchors in Exterior Locations: Stainless-steel bolts complying with ASTM F 593 and nuts complying with ASTM F 594.

## **2.5 MISCELLANEOUS MATERIALS**

- A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
- B. Galvanizing Repair Paint: High-zinc-dust-content paint for regalvanizing welds in steel, complying with The Society for Protective Coatings SSPC-Paint 20 or ASTM A780.

- C. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.
- D. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout specifically recommended by manufacturer for interior and exterior applications.

## **2.6 FABRICATION, GENERAL**

- A. Shop Assembly: Preassemble items in the shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
- B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch, unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
- C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- D. Form exposed work true to line and level with accurate angles and surfaces and straight edges.
- E. Weld corners and seams continuously to comply with the following:
  - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  - 2. Obtain fusion without undercut or overlap.
  - 3. Remove welding flux immediately.
  - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) screws or bolts, unless otherwise indicated. Locate joints where least conspicuous.
- G. Fabricate seams and other connections that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.
- H. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.
- I. Provide for anchorage of type indicated; coordinate with supporting structure. Space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.

## **2.7 MISCELLANEOUS FRAMING AND SUPPORTS**

- A. General: Provide steel framing and supports not specified in other Sections as needed to complete the Work.



- B. Fabricate units from steel shapes, plates, and bars of welded construction, unless otherwise indicated. Fabricate to sizes, shapes, and profiles indicated and as necessary to receive adjacent construction retained by framing and supports. Cut, drill, and tap units to receive hardware, hangers, and similar items.
  - 1. Fabricate units from slotted channel framing where indicated.
  - 2. Furnish inserts if units are installed after concrete is placed.
- C. Fabricate supports for operable partitions from continuous steel beams of sizes indicated with attached bearing plates, anchors, and braces as indicated. Drill bottom flanges of beams to receive partition track hanger rods; locate holes where indicated on operable partition Shop Drawings.

## **2.8 LOOSE BEARING AND LEVELING PLATES**

- A. Provide loose bearing and leveling plates for steel items bearing on masonry or concrete construction. Drill plates to receive anchor bolts and for grouting.

## **2.9 STEEL WELD PLATES AND ANGLES**

- A. Provide steel weld plates and angles not specified in other Sections, for items supported from concrete construction as needed to complete the Work. Provide each unit with not less than two integrally welded steel strap anchors for embedding in concrete.

## **2.10 MISCELLANEOUS STEEL TRIM**

- A. Unless otherwise indicated, fabricate units from steel shapes, plates, and bars of profiles shown with continuously welded joints and smooth exposed edges. Miter corners and use concealed field splices where possible.
- B. Provide cutouts, fittings, and anchorages as needed to coordinate assembly and installation with other work. Provide with integrally welded steel strap anchors for embedding in concrete or masonry construction.

## **2.11 PIPE GUARDS**

- A. Fabricate pipe guards from 3/8-inch-thick by 12-inch wide steel plate, bent to fit flat against the wall or column at both ends and to fit around pipe with 2-inch clearance between pipe and pipe guard. Drill each end for two 3/4-inch anchor bolts.

## **2.12 FINISHES, GENERAL**

- A. Comply with the National Association of Architectural metal Manufacturer's (NAAMM) "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Finish metal fabrications after assembly.

## **2.13 STEEL AND IRON FINISHES**

- A. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with minimum requirements indicated below for SSPC surface preparation specifications and environmental exposure conditions of installed metal fabrications:
1. Exteriors (SSPC Zone 1B) and Items Indicated to Receive Zinc-Rich Urethane Primer: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning".
  2. Interiors (SSPC Zone 1A): SSPC-SP 7, "Brush Off Blast Cleaning".
  3. Apply shop primer to uncoated surfaces of metal fabrications, except those with galvanized finishes and those to be field welded, embedded in concrete or masonry, unless otherwise indicated. Extend priming of partially embedded members to a depth of 2 inches.
  4. Comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel", for shop painting.
  5. Comply with SSPC-PA 2, "Measurement of Dry Coating Thickness with magnetic Gages".
- B. Hot-Dip Galvanizing: For steel exposed to the elements, weather or corrosive environments and other steel indicated to be galvanized, provide coating for iron and steel fabrications applied by the hot-dip process. Comply with ASTM A 123 for fabricated products and ASTM A 153 for hardware. Provide thickness of galvanizing specified in referenced standards. The galvanizing bath shall contain high grade zinc and other earthly materials. Fill vent holes and grind smooth after galvanizing.
- C. Hot-Dip Galvanizing And Factory-Applied Primer for Steel: Provide hot-dip galvanizing and factory-applied prime coat, certified OTC/VOC compliant less than 2.8 lbs/gal. and conforming to EPA and Commonwealth of Massachusetts requirements. Apply primer within 12 hours after galvanizing at the galvanizer's plant in a controlled environment meeting applicable environmental regulations and as recommended by the primer coating manufacturer. Blast cleaning of the surface is unacceptable for surface preparation. Primer shall have a minimum two year re-coat window for application of finish coat. Coatings must meet or exceed the following performance criteria:
1. Abrasion: ASTM D 4060, CS17 Wheel, 1,000 gram load.
  2. Adhesion: ASTM D 3359, Method B, 5 mm crosshatch.
  3. Humidity Resistance: ASTM D 4585.
  4. Salt Spray (Fog): ASTM B 117.
- D. Hot-Dip Galvanizing and Factory-Applied Urethane Primer and Finish for Steel (All Locations): Provide factory-applied architectural coating over primed hot-dip galvanized steel matching approved samples.
1. Primer coat shall be factory-applied polyamide epoxy primer. Apply primer within 12 hours after galvanizing at the galvanizer's plant in a controlled environment meeting applicable environmental regulations and as recommended by the primer coating manufacturer.
  2. Finish coat shall be factory-applied color-pigmented architectural finish. Apply finish coating at the galvanizer's plant, in a controlled environment meeting applicable environmental regulations and as recommended by the finish coating manufacturer.
  3. Coatings shall be certified OTC/VOC compliant and conform to applicable regulations and EPA standards.

4. Apply the galvanizing, primer and coating within the same facility and provide single-source responsibility for galvanizing, priming and finish coating.
  5. Blast cleaning of the galvanized surface is not acceptable.
  6. Primer shall meet or exceed the following performance criteria:
    - a. Abrasion: ASTM D 4060, CS17 Wheel, 1,000 gram load.
    - b. Adhesion: ASTM D 3359, Method B, 5 mm crosshatch.
    - c. Humidity Resistance: ASTM D 4585.
    - d. Salt Spray (Fog): ASTM B 117.
  7. Finish coat shall meet or exceed the following performance criteria:
    - a. Abrasion: ASTM D 4060, CS17 Wheel, 1,000 gram load.
    - b. Adhesion: ASTM D 3359, Method B, 5 mm crosshatch.
    - c. Graffiti Resistance: After drying for seven days, no staining from acrylic, epoxy, epoxy-ester and alkyd spray paints, ballpoint pen, crayons, magic marker, black shoe polish, and lipstick.
    - d. Weathering: ASTM D 1014, 45 degrees facing south.
    - e. Surface Burning Characteristics: ASTM E 84
    - f. QUV: ASTM G53, ES-40 bulbs, 4 hours light, 4 hours dark.
    - g. Salt Spray (Fog): ASTM B 117.
  8. Clearcoat over finish coat shall meet or exceed the following performance criteria:
    - a. Abrasion: ASTM D 4060, CS17 Wheel, 1,000 gram load.
    - b. Adhesion: ASTM D 3359, Method B, 5 mm crosshatch.
    - c. Graffiti Resistance: After drying for seven days, no staining from acrylic, epoxy, epoxy-ester and alkyd spray paints, ballpoint pen, crayons, magic marker, black shoe polish, and lipstick.
    - d. Weathering: ASTM D 1014, 45 degrees facing south; and ASTM D 4141C EMMAQUA-NTW.
    - e. QUV: ASTM G53, ES-40 bulbs, 4 hours light, 4 hours dark.
    - f. Salt Spray (Fog): ASTM B 117.
    - g. Flexibility: ASTM D 522, Method B, cylindrical mandrel.
    - h. Hardness: ASTM D 3363 (Pencil).
- E. Zinc-Rich Primer: Urethane zinc rich primer compatible with topcoat Specified in Section 09900. Provide primer with a VOC content of 340 g/L (2.8 lb/gal.) or less per OTC ozone standards when calculated according to 40 CFR 59, Subpart D (EPA Method 24). Provide Tnemec Series 394 Perimerprime or Ameron Series 68HS at 3.0 mils DFT or approved equal by DuPont or Carboline.

## **2.14 STAINLESS-STEEL FINISHES**

- A. Remove tool and die marks and stretch lines or blend into finish.
- B. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean. Remove all heat tint at welds and heat affected zones.

## **2.15 ALUMINUM FINISHES**

- A. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
- B. High-Performance Organic Finish (3-Coat Fluoropolymer): AA-C12C40R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: conversion coating; Organic Coating: manufacturer's standard 3-coat, thermocured system consisting of specially formulated inhibitive primer, fluoropolymer color coat, and clear fluoropolymer topcoat, with both color coat and clear topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with AAMA 2605 and with coating and resin manufacturers' written instructions. Eight custom colors (2 per station) as selected by the Engineer.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION, GENERAL**

- A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
- B. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
- C. Field Welding: Comply with the following requirements:
  - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  - 2. Obtain fusion without undercut or overlap.
  - 3. Remove welding flux immediately.
  - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction. Provide threaded fasteners for use with concrete and masonry inserts, toggle bolts, through bolts, lag bolts, wood screws, and other connectors.
- E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.
- F. Corrosion Protection: Coat concealed surfaces of aluminum that will come into contact with grout, concrete, masonry, wood, or dissimilar metals with a heavy coat of bituminous paint.

### **3.2 INSTALLING MISCELLANEOUS FRAMING AND SUPPORTS**

- A. General: Install framing and supports to comply with requirements of items being supported, including manufacturer's written instructions and requirements indicated on Shop Drawings.
- B. Anchor supports for operable partitions securely to and rigidly brace from building structure.
- C. Support steel girders on solid grouted masonry, concrete, or steel pipe columns. Secure girders with anchor bolts embedded in grouted masonry or concrete or with bolts through top plates of pipe columns. Where grout space under bearing plates is indicated for girders supported on concrete or masonry, install as specified in this Section.
- D. Install pipe columns on concrete footings with grouted baseplates. Position and grout column baseplates as specified in this Section. Grout baseplates of columns supporting steel girders after girders are installed and leveled

### **3.3 INSTALLING BEARING AND LEVELING PLATES**

- A. Clean concrete and masonry bearing surfaces of bond-reducing materials, and roughen to improve bond to surfaces. Clean bottom surface of plates.
- B. Set bearing and leveling plates on wedges, shims, or leveling nuts. After bearing members have been positioned and plumbed, tighten anchor bolts. Do not remove wedges or shims but, if protruding, cut off flush with edge of bearing plate before packing with grout.
  - 1. Use nonshrink grout, either metallic or nonmetallic, in concealed locations where not exposed to moisture; use nonshrink, nonmetallic grout in exposed locations, unless otherwise indicated.
  - 2. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.

### **3.4 ADJUSTING AND CLEANING**

- A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas. Paint uncoated and abraded areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
  - 1. Apply by brush or spray to provide a minimum 2.0-mil dry film thickness.
- B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 MEASUREMENT**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of all miscellaneous metals for the BRT Stations.

### **END OF SECTION**

## **SECTION 06100**

### **CARPENTRY**

#### **PART I - GENERAL**

##### **1.1 DESCRIPTION OF WORK**

A. This Section specifies the following items:

1. Wood furring.
2. Plywood roof sheathing.

##### **1.2 DEFINITIONS**

- A. Dimension Lumber: Lumber of 2 inches nominal or greater but less than 5 inches nominal in least dimension.
- B. Lumber grading agencies, and the abbreviations used to reference them include the following:

1. ALSC: American Lumber Standard Committee
2. AWWPA: American Wood-Preservers Association
3. DHI: Door and Hardware Institute
4. NELMA: Northeastern Lumber Manufacturers Association
5. NHLA: National Hardware Lumber Association
6. NLGA: National Lumber Grades Authority

##### **1.3 SUBMITTALS**

- A. Submit for each type of process and factory-fabricated product. Indicate component materials and dimensions, and include construction and application details.
1. Include data for wood preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used and net amount of preservative retained.
  2. Include data for fire retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials based on testing by a qualified independent testing agency.
  3. For fire retardant treatments specified to be High-Temperature (HT) type, include physical properties of treated lumber both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency according to ASTM D 5664.
  4. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to project site.
  5. Include copies of warranties from chemical treatment manufacturers for each type of treatment.
- B. For the following products, provide compliance documentation with applicable building and state codes:

1. Preservative treated wood.
2. Power driven fasteners.
3. Powder-actuated fasteners.
4. Expansion anchors.

#### **1.4 DELIVERY, STORAGE, AND HANDLING**

- A. Stack lumber flat with spacers between each bundle to provide air circulation. Provide for air circulation around stacks and under coverings.
- B. Deliver interior wood materials that are to be exposed to view only after building is enclosed and weatherproof, wet work other than painting is dry, and HVAC system is operating and maintaining temperature and humidity at occupancy levels.

### **PART 2- PRODUCTS**

#### **2.1 WOOD PRODUCTS**

- A. Lumber: Provide lumber graded by DOC PS 20 standards and applicable rules of grading agencies. If no grading agency is indicated, provide lumber that complies with the applicable rules of any rules-writing agency certified by the ALSC Board of Review to inspect and grade lumber under the rules indicated.
  1. Factory mark each piece of lumber with grade stamp of grading agency.
  2. For exposed lumber indicated to receive a stained or natural finish, mark grade stamp on end or back of each piece.
  3. Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, produce minimum dressed sizes for dry lumber.
  4. Provide dressed lumber sanded four sides (S4S) unless otherwise indicated.

#### **2.2 WOOD PANEL PRODUCTS**

- A. Plywood: Complying with the requirements of DOC PS 1.
- B. Thickness: As needed to comply with requirements specified, but not less than thickness indicated.
- C. Factory mark panels to indicate compliance with applicable standard.

#### **2.3 WOOD PRESERVATIVE-TREATED MATERIALS**

- A. Preservative Treatment by Pressure Process complying in requirements of AWWA C2.
  1. Preservative Chemicals: Acceptable to the Authority and containing no arsenic or chromium.
- B. Kiln-dry lumber after treatment to maximum moisture content of 19 percent.
- C. Mark lumber with treatment quality mark of an inspection agency approved by the ALSC Board of Review.

- D. Application: Treat miscellaneous carpentry, including the following:
1. Wood sills, sleepers, blocking furring and similar concealed members in contact with masonry or concrete.
  2. Wood framing and furring attached directly to the interior of below-grade exterior masonry or concrete walls.
  3. Wood framing members that are less than 18 inches above the ground in crawl space.
  4. Wood floor plates that are installed over concrete slabs-on grade.

## **2.4 MISCELLANEOUS LUMBER**

- A. General: Provide miscellaneous lumber indicated and lumber for support or attachment of other construction, including the following:
1. Blocking
  2. Nailers
  3. Cants
  4. Furring
- B. For items of dimension lumber size, provide Construction or No.2 grade lumber with 15 percent maximum moisture content and any of the following species:
1. Hem-fir (north); NLGA
  2. Spruce-Pine-fir;NLGA
- C. For concealed boards, provide lumber with 15 percent maximum moisture content and any of the following species and grades:
1. Hem-fir or hem fir (North), Construction or 2 Common grade;NLGA.
  2. Spruce-pine-fir (south) or spruce-pine fir, Construction or 2 common grade; NELMA or NLGA
- D. For blocking not used for attachment of other construction, utility, stud, or No.3 grade lumber of any species may be used provided that it is cut and selected to eliminate defects that will interfere with the attachment and purpose.
- E. For blocking and nailers used for attachment of other construction, select and cut lumber to eliminate knots and other defects that will interfere with attachment of other work.
- F. For furring strips for installing plywood or hardboard paneling, select boards with no knots capable of producing bent-over nails and damage to paneling.
- G. Application: Provide kiln dried lumber in the following locations:
1. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, and waterproofing.

## **2.5 PLYWOOD ROOF SHEATHING**

- A. Roof Sheathing: DOC PS1, Exposure 1, C-D Plugged, pressure preservative treated in thickness indicated; span rated for dimensions indicated on the Drawings.



## **2.6 FASTENERS**

- A. General: Provide fasteners of size and type indicated that comply with requirements specified in this Article for material and manufacture.
  - 1. Where carpentry is exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide fasteners of Type 316 stainless steel.
- B. Nails, Brads, and Staples: Complying with the requirements of ASTM F 1667.
- C. Power-Driven Fasteners: Complying with NES NER-272.
- D. Wood Screws: Complying with the requirements of ASME B18 .6.1.
- E. Screws for Fastening to Cold-Formed Metal Framing: Complying with the requirements ASTM C954, except with wafer heads and reamer wings, length as recommended by screw manufacturer for material to be fastened.
- F. Lag Bolts: Complying with ASME B18. 2.1.
- G. Bolts: Steel bolts complying with ASTM A 307, Grade A; with ASTM A 563 hex nuts and, where indicated flat washers.
- H. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to 6 times the load imposed when installed in unit masonry assemblies and equal to 4 times the load imposed when installed in concrete as determined by testing per ASTM E 488 conducted by a qualified independent testing and inspecting agency.
  - 1. Material : Stainless steel with bolts and nuts complying with ASTM F593 and ASTM F594 Alloy group 1 or 2.

## **PART 3- EXECUTION**

### **3.1 GENERAL**

- A. Set carpentry to required levels and lines with members plumb, true to line, cut, and fitted. Fit carpentry to other construction; scribe and cope as needed for accurate fit. Locate furring, nailers, blocking and similar supports to comply with requirements for attaching other construction.
- B. Provide blocking and framing as indicated and as required to support facing materials, fixtures, specialty items and trim.
- C. Sort and select lumber so that natural characteristics will not interfere with installation or fastening other materials to lumber. Do not use materials with defects that interfere with function of member or pieces that are too small to use with minimum number of joints or optimum joint arrangement.
- D. Comply with AWWA M4 for applying field treatment to cut surfaces of preservative-treated lumber.

1. Use inorganic boron for items that are continuously protected from liquid water.
- E. Securely attach carpentry work to substrate by anchoring and fastening as indicated, complying with the following:
  1. NER-272 for power driven fasteners.
  2. Table 2304.9.1, "Fastening Schedule", in the International Building Code.
- F. Use common wire nails, unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood; do not countersink nail heads, unless otherwise indicated.

### **3.2 WOOD BLOCKING AND NAILER INSTALLATION**

- A. Install where indicated and where required for screeding or attaching other work. Form to shapes indicated and cut as required for true line and level of attached work. Coordinate locations with other work involved.
- B. Attach items to substrates to support applied loading. Recess bolts and nuts flush with surfaces, unless otherwise indicated.

### **3.3 WOOD FURRING INSTALLATION**

- A. Install level and plumb with closure strips at edges and openings. Shim with wood as required for tolerance of finish work.
- B. Furring to Receive Plywood: Install 1-by-3 inch nominal-size furring vertically 24 inches o.c.

### **3.4 PROTECTION**

- A. Protect wood that has been treated with inorganic boron (SBX) from weather. If, despite protection inorganic boron-treated wood becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.
- B. Protect rough carpentry from weather. If despite protection, rough carpentry becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

## **MEASUREMENT AND PAYMENT**

### **4.1 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of the BRT Stations.

## **END OF SECTION**

**SECTION 07500**  
**MEMBRANE ROOFING**

**PART 1 - GENERAL**

**1.1 DESCRIPTION OF WORK**

- A. Work Included: This Section specifies the following.
  - 1. Adhered EPDM membrane roofing system.
  - 2. Roof insulation.
- B. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
  - 1. Section 06100 - CARPENTRY: Wood nailers, curbs, and blocking.
  - 2. Section 07600 - FLASHING SHEET METAL: Metal roof penetration flashings, flashings, and counterflashings.

**1.2 DEFINITIONS**

- A. Roofing Terminology: Refer to ASTM D 1079 and glossary of NRCA's "The NRCA Roofing and Waterproofing Manual" for definition of terms related to roofing work in this Section.

**1.3 PERFORMANCE REQUIREMENTS**

- A. General: Provide installed roofing membrane and base flashings that remain watertight; do not permit the passage of water; and resist specified uplift pressures, thermally induced movement, and exposure to weather without failure.
- B. Material Compatibility: Provide roofing materials that are compatible with one another under conditions of service and application required, as demonstrated by roofing manufacturer based on testing and field experience. Roofing System Design: Roofing system shall be designed to withstand Code required loads and wind speeds.
- D. Flashings: Provide base flashings, perimeter flashings, detail flashings and component materials that comply with requirements and recommendations in FMG 1-49 Loss Prevention Data Sheet for Perimeter Flashings; FMG 1-29 Loss Prevention Data Sheet for Above Deck Roof Components; NRCA Roofing and Waterproofing Manual (Fourth Edition) for Construction Details and SMACNA Architectural Sheet Metal Manual (Fifth Edition) for Construction Details, as applicable.

**1.4 SUBMITTALS**

- A. Product Data: For each type of product indicated.

- B. Shop Drawings: For roofing system. Include plans, elevations, sections, details, and attachments to other Work.
  - 1. Base flashings and membrane terminations.
  - 2. Tapered insulation, including slopes.
  - 3. Insulation fastening patterns.
- C. Installer Certificates: Signed by roofing system manufacturer certifying that Installer is approved, authorized, or licensed by manufacturer to install roofing system.
- D. Qualification Data: For Installer and manufacturer.
- E. Maintenance Data: For roofing system to include in maintenance manuals.
- F. Inspection Report: Copy of roofing system manufacturer's inspection report of completed roofing installation.

## **1.5 QUALITY ASSURANCE**

- A. Source Limitations: Obtain components for roofing system from or approved by roofing system manufacturer.
- B. Preinstallation Conference: Conduct conference at Project site. Comply with requirements in Division 1. Review methods and procedures related to roofing system including, but not limited to, the following:
  - 1. Meet with the Engineer, testing and inspecting agency representative, roofing Installer, roofing system manufacturer's representative, deck Installer, and installers whose work interfaces with or affects roofing including installers of roof accessories and roof-mounted equipment.
  - 2. Review methods and procedures related to roofing installation, including manufacturer's written instructions.
  - 3. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
  - 4. Examine deck substrate conditions and finishes for compliance with requirements, including flatness and fastening.
  - 5. Review structural loading limitations of roof deck during and after roofing.
  - 6. Review base flashings, special roofing details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that will affect roofing system.
  - 7. Review governing regulations and requirements for insurance and certificates if applicable.
  - 8. Review temporary protection requirements for roofing system during and after installation.
  - 9. Review roof observation and repair procedures after roofing installation.

## **1.6 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, and directions for storing and mixing with other components.

- B. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing system manufacturer. Protect stored liquid material from direct sunlight.
  - 1. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.
- C. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.
- D. Handle and store roofing materials and place equipment in a manner to avoid permanent deflection of deck.

## **1.7 PROJECT CONDITIONS**

- A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed according to manufacturer's written instructions and warranty requirements.

## **1.8 WARRANTY**

- A. Special Warranty: Manufacturer's standard form, without monetary limitation (non prorated), in which manufacturer agrees to repair or replace components of roofing system that fail in materials or workmanship within specified warranty period. Failure includes roof leaks.
  - 1. Special warranty includes roofing membrane, base flashings, roofing membrane accessories, roof insulation, fasteners, cover boards, substrate board, vapor retarder, and other components of roofing system.
  - 2. Warranty Period: 20 years from date of Substantial Completion.

# **PART 2 - PRODUCTS**

## **2.1 EPDM ROOFING MEMBRANE**

- A. EPDM Roofing Membrane: ASTM D 4637, Type I, non-reinforced uniform, flexible sheet made from EPDM, and as follows:
  - 1. Thickness: 60 mils (1.5 mm).
  - 2. Exposed Face Color: Black.

## **2.2 AUXILIARY MATERIALS**

- A. General: Auxiliary materials recommended by roofing system manufacturer for intended use and compatible with membrane roofing.
  - 1. Liquid-type auxiliary materials shall meet VOC limits of authorities having jurisdiction.

- B. Sheet Flashing: Manufacturer's standard sheet flashing of same material, type, reinforcement, thickness, and color as PVC sheet membrane.
- C. Bonding Adhesive: Manufacturer's standard bonding adhesive for membrane, and solvent-based bonding adhesive for base flashings.
- D. Metal Termination Bars: Manufacturer's standard predrilled stainless-steel or aluminum bars, approximately 1 by 1/8 inch thick; with anchors.
- E. Fasteners: Factory-coated steel fasteners and metal or plastic plates meeting corrosion-resistance provisions in FMG 4470, designed for fastening membrane to substrate, and acceptable to membrane roofing system manufacturer.
- F. Miscellaneous Accessories: Provide pourable sealers, preformed cone and vent sheet flashings, preformed inside and outside corner sheet flashings, T-joint covers, termination reglets, cover strips, and other accessories.

## **2.3 ROOF INSULATION**

- A. General: Provide preformed roof insulation boards that comply with requirements and referenced standards, selected from manufacturer's standard sizes and of thicknesses indicated.
- B. Polyisocyanurate Board Insulation: ASTM C 1289, Type II, felt or glass-fiber mat facer on both major surfaces.
- C. Tapered Insulation: Provide factory-tapered insulation boards fabricated to slope of 1/4 inch per 12 inches unless otherwise indicated.
- D. Provide preformed saddles, crickets, tapered edge strips, and other insulation shapes where indicated for sloping to drain. Fabricate to slopes indicated.

## **2.4 INSULATION ACCESSORIES**

- A. General: Furnish roof insulation accessories recommended by insulation manufacturer for intended use and compatible with membrane roofing.
- B. Fasteners: Factory-coated steel fasteners and metal or plastic plates meeting corrosion-resistance provisions in FMG 4470, designed for fastening roof insulation to substrate, and acceptable to roofing system manufacturer.
- C. Cold Fluid-Applied Adhesive: Manufacturer's standard cold fluid-applied adhesive formulated to adhere roof insulation to substrate.

# **PART 3 - EXECUTION**

## **3.1 EXAMINATION**

- A. Examine substrates, areas, and conditions, with Installer present, for review of conditions affecting performance of roofing system.

### **3.2 PREPARATION**

- A. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing installation according to roofing system manufacturer's written instructions. Remove sharp projections.

### **3.3 INSULATION INSTALLATION**

- A. Coordinate installing membrane roofing system components so insulation is not exposed to precipitation or left exposed at the end of the workday.
- B. Comply with membrane roofing system manufacturer's written instructions for installing roof insulation.
- C. Install tapered insulation under area of roofing to conform to slopes indicated.
- D. Install one or more layers of insulation under area of roofing to achieve required thickness. Install 2 or more layers with joints of each succeeding layer staggered from joints of previous layer a minimum of 6 inches in each direction.
- E. Trim surface of insulation where necessary at roof drains so completed surface is flush and does not restrict flow of water.
- F. Install insulation with long joints of insulation in a continuous straight line with end joints staggered between rows, abutting edges and ends between boards. Fill gaps exceeding 1/4 inch with insulation.
  - 1. Cut and fit insulation within 1/4 inch of nailers, projections, and penetrations.
- G. Mechanically Fastened Insulation: Install each layer of insulation and secure to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
  - 1. Fasten insulation according to requirements in FMG's "Approval Guide" for specified Windstorm Resistance Classification.
  - 2. Fasten insulation to resist uplift pressure at corners, perimeter, and field of roof.

### **3.4 ADHERED ROOFING MEMBRANE INSTALLATION**

- A. Install roofing membrane over area to receive roofing according to membrane roofing system manufacturer's written instructions. Unroll roofing membrane and allow to relax before installing.
- B. Accurately align roofing membrane and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.
- C. Bonding Adhesive: Apply solvent-based bonding adhesive to substrate and underside of roofing membrane at rate required by manufacturer and allow to partially dry before installing roofing membrane. Do not apply bonding adhesive to splice area of roofing membrane.
- D. Mechanically or adhesively fasten roofing membrane securely at terminations, penetrations, and perimeter of roofing.

- E. Apply roofing membrane with side laps shingled with slope of roof deck where possible.
- F. Seams: Clean seam areas, overlap roofing membrane, and hot-air weld side and end laps of roofing membrane according to manufacturer's written instructions to ensure a watertight seam installation.
  - 1. Test lap edges with probe to verify seam weld continuity. Apply lap sealant to seal cut edges of roofing membrane.
  - 2. Verify field strength of seams a minimum of twice daily and repair seam sample areas.
  - 3. Repair tears, voids, and lapped seams in roofing membrane that does not meet requirements.

### **3.5 BASE FLASHING INSTALLATION**

- A. Install sheet flashings and preformed flashing accessories and adhere to substrates according to membrane roofing system manufacturer's written instructions.
- B. Apply solvent-based bonding adhesive to substrate and underside of sheet flashing at required rate and allow to partially dry. Do not apply bonding adhesive to seam area of flashing.
- C. Flash penetrations and field-formed inside and outside corners with cured or uncured sheet flashing.
- D. Clean splice areas, apply splicing cement, and firmly roll side and end laps of overlapping sheets to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of sheet flashing terminations.
- E. Terminate and seal top of sheet flashings.

### **3.6 FIELD QUALITY CONTROL**

- A. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion and submit report to Engineer.
  - 1. Notify Engineer 48 hours in advance of date and time of inspection.
- B. Repair or remove and replace components of membrane roofing system where test results or inspections indicate that they do not comply with specified requirements.
- C. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

### **3.7 PROTECTING AND CLEANING**

- A. Protect membrane roofing system from damage and wear during remainder of construction period. When remaining construction will not affect or endanger roofing, inspect roofing for deterioration and damage, describing its nature and extent in a written report, with copies to Engineer.



- B. Correct deficiencies in or remove membrane roofing system that does not comply with requirements, repair substrates, and repair or reinstall membrane roofing system to a condition free of damage and deterioration at time of Substantial Completion and according to warranty requirements.
- C. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations.

## **END OF SECTION**

**SECTION 07600**  
**FLASHING AND SHEET METALS**

**PART 1 - GENERAL**

**1.1 SCOPE OF WORK**

- A. Provide all labor, equipment, and materials fabricate and install the following.
  - 1. Edge strip and flashing.
  - 2. Fascia and trim.
  - 3. Counter-flashings for roof accessories.
  - 4. Base flashing coverings.
  - 5. Fascia and edge metal.
  - 6. Metal composite panels
  - 7. Other components.
- B. Related Work: The following items are not included in the Section and will be performed under the designated Sections:
  - 1. Section 05100 – Structural Steel
  - 2. Section 05500 – Miscellaneous Metals
  - 3. Section 08801 – Glass and Glazing

**1.2 REFERENCES**

ASTM A-446	Specification for steel sheet
ASTM B-209	Specification for aluminum sheet
ASTM B-221	Specification for aluminum extruded shape
ASTM A792	Steel Sheet, Aluminum-Zinc Alloy-Coated, by the Hot-Dip Process
ASTM B32	Solder Metal
ASTM B209	Aluminum and Alloy Sheet and Plate
ASTM B486	Paste Solder
FS O-F-506	Flux, Soldering, Paste and Liquid
FM	Loss Prevention Data Sheet
NRCA	National Roofing Contractors Association - Roofing Manual
SMACNA	Architectural Sheet Metal Manual

**1.3 SUBMITTALS**

- A. Submit under provisions of Section 01300 - Submittals.
- B. Product Data: Provide manufacturer's specification data sheets for each product in accordance with Section 01300.
- C. Provide approval letters from metal manufacturer for use of their metal within this particular roofing system type.

- D. Submit two samples, 12 x 12 inch in size illustrating typical external corner, internal corner, valley, junction to vertical dissimilar surface, material and finish.
- E. Shop Drawings
  - 1. For manufactured and shop fabricated gravel stops, fascia, scuppers, and all other sheet metal fabrications.
  - 2. Shop drawings: Indicate material profile, jointing pattern, jointing details, fastening methods, flashing, termination's, and installation details.
  - 3. Indicate type, gauge and finish of metal.
- F. Certification
  - 1. Submit roof manufacturer's certification that metal fasteners furnished are acceptable to roof manufacturer.
  - 2. Submit roof manufacturer's certification that metal furnished is acceptable to roofing manufacturer as a component of roofing system and is eligible for roof manufacturer's system warranty.
  - 3. Submit certification that metal and fastening system furnished is Tested and Approved by Factory Mutual for 1-90 Wind Up-Lift Requirements.
- G. Manufacturer's Product Data
  - 1. Metal material characteristics and installation recommendations.
  - 2. Submit color chart prior to material ordering and/or fabrication so that equivalent colors to those specified can be approved.

## **1.4 QUALITY CONTROL**

- A. Reference Standards
  - 1. Comply with details and recommendations of SMACNA Manual for workmanship, methods of joining, anchorage, provisions for expansion, etc.
  - 2. Factory Mutual Loss Prevention Data Sheet 1-49 windstorm resistance 1-90.
- B. Contractor's Warranty
  - 1. The Contractor shall provide the Owner with a notarized written warranty assuring that all sheet metal work including caulking and fasteners to be watertight and secure for a period of two years from the date of final acceptance of the building. Warranty shall include all materials and workmanship required to repair any leaks that develop, and make good any damage to other work or equipment caused by such leaks or the repairs thereof.

## **1.5 QUALIFICATIONS**

- A. Fabricator and Installer: Company specializing in sheet metal flashing work.

## **1.6 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver materials in manufacturer's original, unopened containers or packages with labels intact and legible.
- B. Stack pre-formed and pre-finished material to prevent twisting, bending, or abrasion, and to provide ventilation. Slope metal sheets to ensure drainage.
- C. Prevent contact with materials which may cause discoloration or staining.

## **PART 2 - PRODUCTS**

### **2.1 APPROVED EQUIVALENT**

- A. Contractor must submit any product not specified to Architect in order for product to be considered for approval. The Architect will notify Contractor, in writing, of decision to accept or reject request.

### **2.2 MATERIALS**

- A. Aluminum Sheet: ASTM B 209, Alloy 3003, 3004, 3105, or 5005. Thickness as specified in this Section. Temper suitable for forming and structural performance required, but not less than H14. Thickness as engineered for load and service, but not less than 0.050 inch thick.
- B. Fluoropolymer Three-Coat Finish System: Manufacturer's standard three-coat, thermocured system consisting of specially formulated inhibitive primer, fluoropolymer color coat, and clear fluoropolymer topcoat, with both color coat and clear topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight, with a minimum total dry film thickness of 1.5 mil; complying with AAMA 2605. Eight custom colors (2 per station) as selected by the Engineer.

### **2.3 RELATED MATERIALS**

- A. Aluminum-Faced Composite Panels: Smooth surface, formed with 0.020-inch-thick, coil-coated aluminum sheet facings, panel thickness 0.157 inch (4 mm). Panels shall be factory-formed and -assembled metal-faced composite wall panels fabricated from two metal facings bonded, using no glues or adhesives, to solid extruded thermoplastic core; formed into profile for installation method indicated. Include attachment system components and accessories required for weathertight system.
- B. Fluoropolymer Three-Coat Finish System: Manufacturer's standard three-coat, thermocured system consisting of specially formulated inhibitive primer, fluoropolymer color coat, and clear fluoropolymer topcoat, with both color coat and clear topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight, with a minimum total dry film thickness of 1.5 mil; complying with AAMA 2605. Eight custom colors (2 per station) as selected by Architect.

- C. Attachment System Components: Formed from extruded aluminum. Include manufacturer's standard perimeter extrusions, panel stiffeners, panel clips and anchor channels.
- D. Trim: Same material, finish, and color as facings of adjacent composite panels, unless otherwise indicated.
- E. Fasteners: Self-tapping screws, bolts, nuts, self-locking rivets and bolts, end-welded studs, and other suitable fasteners designed to withstand design loads. Provide concealed fasteners; except where unavoidable, provide exposed fasteners with heads matching color of metal wall panels by means of plastic caps or factory-applied coating

## **2.4 RELATED MATERIALS**

- A. Plastic Cement: ASTM D 4586.
- B. Sealant: Specified in Section 07900 or on drawings.
- C. Solder: ANSI/ASTM B32; 95/05 type.
- D. Flux: FS O-F-506.
- E. Underlayment: ASTM D2178, No15 asphalt saturated roofing felt.
- F. Slip Sheet: Rosin sized building paper.
- G. Fasteners:
  - 1. Corrosion resistant screw fastener as recommended by metal manufacturer. Finish exposed fasteners same as flashing metal.
  - 2. Fastening shall conform to Factory Mutual 1-90 requirements or as stated on section details, whichever is more stringent.
- H. Termination Bars:
  - 1. Shall be aluminum unless otherwise recommended by membrane manufacturers.
  - 2. Material shall be .125" x 1" (minimum) aluminum conforming to ASTM B-221, mill finish. Bar shall have caulk cup as required.

## **PART 3 - EXECUTION**

### **3.1 PROTECTION**

- A. Protect contact areas of dissimilar metals with heavy asphalt or other approved coating, specifically made to stop electrolytic action.

### **3.2 GENERAL**

- A. Install work watertight, without waves, warps, buckles, fastening stress, or distortion, allowing for expansion and contraction.
- B. Fastening of metal to walls and wood blocking shall comply with SMACNA Architectural Sheet Metal Manual, Factory Mutual I-90 wind uplift specifications and/or manufacturer's recommendations whichever is of the highest standard.
- C. All accessories or other items essential to the completeness of sheet metal installation, whether specifically indicated or not, shall be provided and of the same material as item to which applied.
- D. Metal fascia and copings shall be secured to wood nailers at the bottom edge with a continuous cleat. Cleats shall be at least one gauge heavier than the metal it secures.

### **3.3 INSPECTION**

- A. Verify roof openings, curbs, pipes, sleeves, ducts, or vents through roof are solidly set, cant strips and reglets are in place, and nailing strips located.
- B. Verify membrane termination and base flashings are in place, sealed, and secure.
- C. Beginning of installation means acceptance of existing conditions.
- D. Field measure site conditions prior to fabricating work.

### **3.4 SHOP FABRICATED SHEET METAL**

- A. Installing Contractor shall be responsible for determining if the sheet metal systems are in general conformance with roof manufacturer's recommendations.
- B. Metal work shall be shop fabricated to configurations and forms in accordance with recognized sheet metal practices.
- C. Hem exposed edges.
- D. Angle bottom edges of exposed vertical surfaces to form drip.
- E. All corners for sheet metal shall be lapped with adjoining pieces fastened and set in sealant.
- F. Joints for gravel stop fascia system, cap flashing, and surface-mount counterflashing shall be formed with a 1/4" opening between sections. The opening shall be covered by a cover plate or backed by an internal drainage plate formed to the profile of fascia piece. The cover plate shall be embedded in mastic, fastened through the opening between the sections and loose locked to the drip edges.
- G. Install sheet metal to comply with Architectural Sheet Metal manual, Sheet Metal and Air Conditioning Contractor's National Associations, Inc.

### **3.5 METAL PANEL INSTALLATION**

- A. General: Install panels in orientation, sizes, and locations indicated on Drawings. Install panels perpendicular to girts and subgirts, unless otherwise indicated. Anchor metal wall panels and other components of the Work securely in place, with provisions for thermal and structural movement.
- B. Field cutting of metal panels by torch is not permitted. Shim or otherwise plumb substrates receiving metal panels. Rigidly fasten base end of metal panels and allow eave end free movement due to thermal expansion and contraction. Predrill panels. Install screw fasteners in predrilled holes. Locate and space fastenings in uniform vertical and horizontal alignment. Install flashing and trim as metal panel work proceeds

### **3.6 FLASHING MEMBRANE INSTALLATION**

- A. Metal Edge Detail
  - 1. See details for scuppers. For manufactured edge metal, scuppers shall be factory fabricated.
  - 2. Accessories: Joint covers, corners, supports, strip flashing at joining, fastenings and other accessories shall be included.
  - 3. Install continuous cleat fasten 6" O.C. Fasten flange to wood nailer every 6" staggered.
  - 4. Install new metal edge hooked to continuous cleat.
  - 5. Prime metal edge at a rate of 100 square feet per gallon and allow to dry.
- B. Coping Cap/ Surface Mounted Counter-flashing
  - 1. Copings shall be provided with factory fabricated welded watertight coping accessories such as miters, transitions, end caps, etc. and finished to match coping system.
  - 2. Accessories: Joint covers, corners, supports, strip flashing at joinings, fastening, and other accessories shall be included.
  - 3. Install continuous cleat fasten 6" O.C.
  - 4. Install new coping cap hooked to continuous cleat.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit StationS.

### **END OF SECTION**

**SECTION 08801**  
**GLASS AND GLAZING**

**PART 1 - GENERAL**

**1.1 DESCRIPTION OF WORK**

- A. Work Included: This Section specifies the following items.
1. Glass and glazing for the following products and applications:
    - a. Tempered safety laminated glass panels at station canopy roofs; including metal supports and point supports.
    - b. Tempered safety laminated glass panels at platform passenger shelters
    - c. Tempered safety laminated glass panels at station signage
- B. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
1. Section 05500 – Miscellaneous Metals
  2. Section 07600 – Flashing and Sheet Metals

**1.2 DEFINITIONS**

- A. Manufacturers of Glass Products: Firms that produce primary glass, fabricated glass, or both, as defined in referenced glazing publications.
- B. Glass Thicknesses: Indicated by thickness designations in millimeters according to ASTM C 1036.
- C. Deterioration of Coated Glass: Defects developed from normal use that are attributed to the manufacturing process and not to causes other than glass breakage and practices for maintaining and cleaning coated glass contrary to manufacturer's written instructions. Defects include peeling, cracking, and other indications of deterioration in metallic coating.
- D. Deterioration of Insulating Glass: Failure of hermetic seal under normal use that is attributed to the manufacturing process and not to causes other than glass breakage and practices for maintaining and cleaning insulating glass contrary to manufacturer's written instructions. Evidence of failure is the obstruction of vision by dust, moisture, or film on interior surfaces of glass.
- E. Deterioration of Laminated Glass: Defects developed from normal use that are attributed to the manufacturing process and not to causes other than glass breakage and practices for maintaining and cleaning laminated glass contrary to manufacturer's written instructions. Defects include edge separation, delamination materially obstructing vision through glass, and blemishes exceeding those allowed by referenced laminated-glass standard.



### 1.3 PERFORMANCE REQUIREMENTS

- A. General: Provide glazing systems capable of withstanding normal thermal movement and wind and impact loads without failure, including loss or glass breakage attributable to the following: defective manufacture, fabrication, and installation; failure of sealants or gaskets to remain watertight and airtight; deterioration of glazing materials; or other defects in construction.
- B. Glass Design: Glass thickness designations indicated are minimums and are for detailing only. Confirm glass thicknesses by analyzing Project loads and in-service conditions. Provide glass lites in the thickness designations indicated for various size panels, but not less than thicknesses and in strengths (annealed or heat treated) required to meet or exceed the following criteria:
  - 1. Glass Thicknesses: Select minimum glass thicknesses to comply with ASTM E 1300, according to the following requirements:
    - a. Specified Design Wind Loads: As required by Code.
    - b. Specified Design Snow Loads for Sloped Glazing: As required by Code.
    - c. Probability of Breakage for Vertical Glazing: 8 lites per 1000 for lites set vertically or not more than 15 degrees off vertical and under wind action.
      - 1) Load Duration: 60 seconds minimum.
    - d. Probability of Breakage for Sloped Glazing: 1 lite per 1000 for lites set more than 15 degrees off vertical and under wind and snow action.
      - 1) Load Duration: 30 days minimum.
    - e. Maximum Lateral Deflection: For the following types of glass supported on all 4 edges, provide thickness required that limits center deflection at design wind pressure to 1/50 times the short side length or 1 inch, whichever is less.
      - 1) For monolithic-glass lites heat treated to resist wind loads.
      - 2) For laminated-glass lites.
    - f. Minimum Glass Thickness for Exterior Lites: Not less than 6 mm.
    - g. Vertical glass lites at signage Type B shall resist a bending moment of 600 lb/ft.
    - h. Edgework: All exposed edges shall be ground smooth and polished.
  - C. Thermal Movements: Provide glazing that allows for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures acting on glass framing members and glazing components. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
    - 1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

- D. Thermal and Optical Performance Properties: Provide glass with performance properties specified based on manufacturer's published test data, as determined according to procedures indicated below:
1. For monolithic-glass lites, properties are based on units with lites 6.0 mm thick.
  2. For laminated-glass lites, properties are based on products of construction indicated.
  3. Optical Performance Properties:
    - a. All sloped glazing shall provide controlled light transmission utilizing continuous translucent film.
    - b. Translucent film shall provide approximately 40% of light transmission and shall not be exposed directly to weather conditions.
    - c. If utilizing laminated glass, films shall be introduced in the interlayer as manufactured by a licensed laminated glass manufacturer.
- E. General Performance for Point-Supported Glazing: Canopy glazing assemblies shall withstand movements of supporting structure without failure due to defective manufacture, fabrication, installation, or other defects in construction.
1. Canopy Glazing Assemblies: Comply with performance requirements specified, as determined by testing manufacturer's standard assemblies representing those indicated for this Project. Failures include, but are not limited to, the following: Thermal stresses transferring to building structure; Glass breakage; Noise or vibration created by wind and thermal and structural movements; Loosening or weakening of fasteners, attachments, and other components; Glazing-to-glazing contact.
  2. Delegated Design: Design the structural glazing system and architecturally exposed steel structure and applicable other components for the locations and conditions shown in the architectural and structural drawings and to the loading requirements and codes specified in the documents. Design glass, including comprehensive engineering analysis according to ASTM E 1300 and ICC's 2003 International Building Code by a qualified professional engineer, using the following design criteria: Determine design wind pressures applicable to Project according to ASCE/SEI 7, based on heights above grade indicated on Drawings. Wind and Snow Design Data: As indicated on Drawings

#### **1.4 SUBMITTALS**

- A. Product Data: For each glass product and glazing material indicated.
- B. Samples: For each product, in the form of 12-inch- square Samples for glass.
- C. Glazing Schedule: Use same designations indicated on Drawings in preparing a schedule listing glass types and thicknesses for each size and location.
- D. Product Certificates: Signed by manufacturers of glass and glazing products certifying that products furnished comply with requirements.
- E. Qualification Data: For installers, in accordance with Par. 1.5A.

- F. Preconstruction Adhesion and Compatibility Test Report: From glazing sealant manufacturer indicating glazing sealants were tested for adhesion to glass and glazing channel substrates and for compatibility with glass and other glazing materials.
- G. Product Test Reports: For each type of the following types of glazing products and support system.
- H. Warranties: Special warranties specified in this Section.
- I. Shop Drawings: For all glazing assemblies. Include plans, elevations, sections, details, and attachments to other work.
  - 1. Include details of provisions for assembly expansion and contraction and for draining moisture within the assembly to the exterior.
  - 2. Include full-size isometric details of each vertical-to-horizontal intersection of assembly, showing the following: Joinery including concealed welds; Anchorage; Expansion provisions; Glazing.
  - 3. Include details of supports and data to show provisions for vertical and horizontal expansion/contraction and building movements as necessary.
  - 4. Identify plans, elevations, sections, details and attachments to other work.
- J. Delegated-Design Submittal: For Canopy glazing assemblies indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- K. Structural Calculations: Prior to fabrication of the structural glazing and architecturally exposed steel structure, submit design calculations prepared in accordance with current design rules for structural glazing and applicable codes as called for by the Project Engineer. Include analysis and design for all combinations of load cases such as live, dead, wind, thermal, seismic, and other Code requirements.
  - 1. Supply structural reactions in each axis, at each typical support, for review and acceptance by the Project Engineer, and the maximum glass deflections in all axis.
  - 2. Supply calculations for support and other details as necessary.
  - 3. Glass panel and architecturally exposed structural steel thicknesses shall be sized by the Structural Glass Contractor.
  - 4. Existing text reports are only acceptable as proof of capacity calculations, but will not be acceptable in lieu of calculations.
  - 5. Installation Drawings: After approval of shop drawings, provide a detailed set of field installation drawings and a written installation procedure. Identify each part by size and number.
- L. Replacement Panels for Small Shelters: Provide letter signed by glass manufacturer indicating that replacement panels for small shelters will be available within 5 working days of request.

## 1.5 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer with experience who has completed glazing similar in material, design, and extent to that indicated for this Project; whose

work has resulted in glass installations with a record of successful in-service performance.

- B. Source Limitations for Glass: Obtain the following through one source from a single manufacturer for each glass type: clear float glass, laminated glass and insulating glass.
- C. Source Limitations for Glazing Accessories: Obtain glazing accessories through one source from a single manufacturer for each product and installation method indicated.
- D. Elastomeric Glazing Sealant Product Testing: Obtain sealant test results for product test reports in Part 1 "Submittals" Article from a qualified testing agency based on testing current sealant formulations within a 36-month period.
  - 1. Sealant Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1021 to conduct the testing indicated, as documented according to ASTM E 548.
  - 2. Test elastomeric glazing sealants for compliance with requirements specified by reference to ASTM C 920, and where applicable, to other standard test methods.
- E. Hold Point - Preconstruction Adhesion and Compatibility Testing: Submit to elastomeric glazing sealant manufacturers, for testing indicated below, samples of each glazing material type, tape sealant, gasket, glazing accessory, and glass-framing member that will contact or affect elastomeric glazing sealants:
  - 1. Use ASTM C 1087 to determine whether priming and other specific joint preparation techniques are required to obtain rapid, optimum adhesion of glazing sealants to glass, tape sealants, gaskets, and glazing channel substrates.
  - 2. Submit not fewer than eight pieces of each type of material, including joint substrates, shims, joint-sealant backings, secondary seals, and miscellaneous materials.
  - 3. Schedule sufficient time for testing and analyzing results to prevent delaying the Work.
  - 4. For materials failing tests, obtain sealant manufacturer's written instructions for corrective measures, including the use of specially formulated primers.
  - 5. Testing will not be required if elastomeric glazing sealant manufacturers submit data based on previous testing of current sealant products for adhesion to, and compatibility with, glazing materials matching those submitted.
- F. Safety Glazing Products: Comply with testing requirements in 16 CFR 120.
  - 1. Subject to compliance with requirements, obtain safety glazing products permanently marked with certification label of the Safety Glazing Certification Council or another certification agency acceptable to authorities having jurisdiction.
  - 2. Where glazing units, including Kind FT glass and laminated glass, are specified in Part 2 articles for glazing lites more than 9 sq. ft. in exposed surface area of one side, provide glazing products that comply with Category II materials, for lites 9 sq. ft. or less in exposed surface area of one side, provide glazing products that comply with Category I or II materials, except for hazardous locations where Category II materials are required by 16 CFR 1201 and regulations of authorities having jurisdiction.

- G. Glazing Publications: Comply with published recommendations of glass product manufacturers and organizations below, unless more stringent requirements are indicated. Refer to these publications for glazing terms not otherwise defined in this Section or in referenced standards.
1. GANA Publications: GANA Laminated Division's "Laminated Glass Design Guide" and GANA's "Glazing Manual."
  2. AAMA Publications: AAMA GDSG-1, "Glass Design for Sloped Glazing," and AAMA TIR-A7, "Sloped Glazing Guidelines."
  3. IGMA Publication for Sloped Glazing: IGMA TB-3001, "Sloped Glazing Guidelines."
- H. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1.

## **1.6 DELIVERY, STORAGE, AND HANDLING**

- A. Protect glazing materials according to manufacturer's written instructions and as needed to prevent damage to glass and glazing materials from condensation, temperature changes, direct exposure to sun, or other causes.

## **1.7 PROJECT CONDITIONS**

- A. Environmental Limitations: Do not proceed with glazing when ambient and substrate temperature conditions are outside limits permitted by glazing material manufacturers and when glazing channel substrates are wet from rain, frost, condensation, or other causes. Do not install liquid glazing sealants when ambient and substrate temperature conditions are outside limits permitted by glazing sealant manufacturer or below 40 deg F.

## **1.8 WARRANTY**

- A. Manufacturer's Special Warranty for Coated-Glass Products: Manufacturer's standard form, made out to the Authority and signed by coated-glass manufacturer agreeing to replace coated-glass units that deteriorate as defined in "Definitions" Article, f.o.b. the nearest shipping point to Project site, within specified warranty period indicated below.
1. Warranty Period: Ten years from date of Substantial Completion.
- B. Manufacturer's Special Warranty on Laminated Glass: Manufacturer's standard form, made out to the Authority and signed by laminated-glass manufacturer agreeing to replace laminated-glass units that deteriorate as defined in Part 1 "Definitions" Article, f.o.b. the nearest shipping point to Project site, within specified warranty period indicated below.
1. Warranty Period: Five years from date of Substantial Completion.

## **PART 2 - PRODUCTS**

### **2.1 GLAZING SEALANTS**

- A. General: Provide products of type indicated, complying with the following requirements:
  - 1. Compatibility: Verify glazing sealants that are compatible with one another and with other materials they will contact, including glass products, seals of insulating-glass units, and glazing channel substrates, under conditions of service and application, as demonstrated by sealant manufacturer based on testing and field experience.
  - 2. Suitability: Comply with sealant and glass manufacturers' written instructions for selecting glazing sealants suitable for applications indicated and for conditions existing at time of installation.
  - 3. Colors of Exposed Glazing Sealants: As selected by Engineer from manufacturer's full range.
- B. Elastomeric Glazing Sealants: Comply with ASTM C 920 and other requirements indicated for each liquid-applied chemically curing sealant specified, including those referencing ASTM C 920 classifications for type, grade, class, and uses related to exposure and joint substrates.
  - 1. Single-Component Neutral- and Basic-Curing Silicone Glazing Sealants:
    - a. Dow Corning Corporation; 790.
    - b. GE Silicones; SilPruf LM SCS2700.
    - c. Tremco; Spectrem 1 (Basic).

### **2.2 GLAZING TAPES**

- A. Back-Bedding Mastic Glazing Tapes: Preformed, butyl-based elastomeric tape with a solids content of 100 percent; nonstaining and nonmigrating in contact with nonporous surfaces; with or without spacer rod as recommended in writing by tape and glass manufacturers for application indicated; packaged on rolls with a release paper backing; and complying with ASTM C 1281 and AAMA 800 for project conditions.
- B. Expanded Cellular Glazing Tapes: Closed-cell, PVC foam tapes; factory coated with adhesive on both surfaces; packaged on rolls with release liner protecting adhesive; and complying with AAMA 800 for the following types:
  - 1. Type 1, for glazing applications in which tape acts as the primary sealant.
  - 2. Type 2, for glazing applications in which tape is used in combination with a full bead of liquid sealant.

### **2.3 MISCELLANEOUS GLAZING MATERIALS**

- A. General: Provide products of material, size, and shape complying with referenced glazing standard, requirements of manufacturers of glass and other glazing materials for application indicated, and with a proven record of compatibility with surfaces contacted in installation.

- B. Cleaners, Primers, and Sealers: Types recommended by sealant or gasket manufacturer.
- C. Setting Blocks: Elastomeric material with a Shore, Type A durometer hardness of 85, plus or minus 5.
- D. Spacers: Elastomeric blocks or continuous extrusions with a Shore, Type A durometer hardness required by glass manufacturer to maintain glass lites in place for installation indicated.
- E. Edge Blocks: Elastomeric material of hardness needed to limit glass lateral movement (side walking).

## **2.4 FABRICATION OF GLAZING UNITS**

- A. Fabricate glazing units in sizes required to glaze panels indicated for Project, with edge and face clearances, edge and surface conditions, and bite complying with written instructions of product manufacturer and referenced glazing publications, to comply with system performance requirements.
- B. Clean-cut or flat-grind vertical edges of butt-glazed monolithic lites in a manner that produces square edges with slight kerfs at junctions with outdoor and indoor faces.
- C. Grind smooth and polish exposed glass edges and corners.

## **2.5 POINT SUPPORTED GLASS**

- A. Glazing Attachment: To prevent bending stresses at the glass holes, the glass attachment bolts shall be grade A316 stainless steel and able to rotate up to 10 degrees in any direction or to an angle as required by the application. The stainless steel shall be separated from the glass with durable and UV resistant rings. The glass hole ring shall be anodized aluminum and the other rings shall be silicone, nylon or as required. Where rotational fittings are not used, calculations shall be provided that show the glass fixing bolt does not locally impact the glass stresses, and that the connection is able to flex sufficiently in the glass deformed shape without depending on rubber, plastic bushing or similar materials, remaining durable long term. Bolt diameters shall be per structural requirements.

# **PART 3 - EXECUTION**

## **3.1 EXAMINATION**

- A. Examine framing glazing, with Installer present, for compliance with the following:
  - 1. Manufacturing and installation tolerances, including those for size, squareness, and offsets at corners.
  - 2. Presence and functioning of weep system.
  - 3. Minimum required face or edge clearances.
  - 4. Effective sealing between joints of glass-framing members.

- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 PREPARATION**

- A. Clean glazing channels and other framing members receiving glass immediately before glazing. Remove coatings not firmly bonded to substrates.

### **3.3 GLAZING, GENERAL**

- A. Comply with combined written instructions of manufacturers of glass, sealants, gaskets, and other glazing materials, unless more stringent requirements are indicated, including those in referenced glazing publications.
- B. Glazing channel dimensions, as indicated on Drawings, provide necessary bite on glass, minimum edge and face clearances, and adequate sealant thicknesses, with reasonable tolerances. Adjust as required by Project conditions during installation.
- C. Protect glass edges from damage during handling and installation. Remove damaged glass from Project site and legally dispose of off Project site. Damaged glass is glass with edge damage or other imperfections that, when installed, could weaken glass and impair performance and appearance.
- D. Apply primers to joint surfaces where required for adhesion of sealants, as determined by preconstruction sealant-substrate testing.
- E. Install setting blocks in sill rabbets, sized and located to comply with referenced glazing publications, unless otherwise required by glass manufacturer. Set blocks in thin course of compatible sealant suitable for heel bead.
- F. Do not exceed edge pressures stipulated by glass manufacturers for installing glass lites.
- G. Provide spacers for glass lites where length plus width is larger than 50 inches as follows:
  - 1. Locate spacers directly opposite each other on both inside and outside faces of glass. Install correct size and spacing to preserve required face clearances, unless gaskets and glazing tapes are used that have demonstrated ability to maintain required face clearances and to comply with system performance requirements.
  - 2. Provide 1/8-inch minimum bite of spacers on glass and use thickness equal to sealant width. With glazing tape, use thickness slightly less than final compressed thickness of tape.
- H. Provide edge blocking where indicated or needed to prevent glass lites from moving sideways in glazing channel, as recommended in writing by glass manufacturer and according to requirements in referenced glazing publications.
- I. Set glass lites in each series with uniform pattern, draw, bow, and similar characteristics.



### **3.4 TAPE GLAZING**

- A. Position tapes on fixed stops so that, when compressed by glass, their exposed edges are flush with or protrude slightly above sightline of stops.
- B. Install tapes continuously, but not necessarily in one continuous length. Do not stretch tapes to make them fit opening.
- C. Cover vertical framing joints by applying tapes to heads and sills first and then to jambs. Cover horizontal framing joints by applying tapes to jambs and then to heads and sills.
- D. Place joints in tapes at corners of opening with adjoining lengths butted together, not lapped. Seal joints in tapes with compatible sealant approved by tape manufacturer.
- E. Do not remove release paper from tape until just before each glazing unit is installed.
- F. Center glass lites in openings on setting blocks and press firmly against tape by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings.

### **3.5 SEALANT GLAZING (WET)**

- A. Install continuous spacers, or spacers combined with cylindrical sealant backing, between glass lites and glazing stops to maintain glass face clearances and to prevent sealant from extruding into glass channel and blocking weep systems until sealants cure. Secure spacers or spacers and backings in place and in position to control depth of installed sealant relative to edge clearance for optimum sealant performance.
- B. Force sealants into glazing channels to eliminate voids and to ensure complete wetting or bond of sealant to glass and channel surfaces.
- C. Tool exposed surfaces of sealants to provide a substantial wash away from glass.

### **3.6 POINT SUPPORTED GLASS**

- A. Erect glazing, supports and accessory items in strict accordance with the approved shop/installation drawings and installation procedures. Glass shall not be positioned by the use of force. Provide temporary bracing and support as required to ensure stability during installation process.

### **3.7 CLEANING AND PROTECTION**

- A. Protect exterior glass from damage immediately after installation by attaching crossed streamers to framing held away from glass. Do not apply markers to glass surface. Remove nonpermanent labels, and clean surfaces.
- B. Protect glass from contact with contaminating substances resulting from construction operations, including weld splatter. If, despite such protection, contaminating substances

do come into contact with glass, remove substances immediately as recommended by glass manufacturer.

- C. Examine glass surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less than once a month, for buildup of dirt, scum, alkaline deposits, or stains; remove as recommended in writing by glass manufacturer.
- D. Remove and replace glass that is broken, chipped, cracked, or abraded or that is damaged from natural causes, accidents, and vandalism, during construction period.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Station. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of all glass and glazing elements for the BRT Stations.

## **END OF SECTION**

**SECTION 09360**  
**MODULAR TACTILE SURFACES**

**PART 1 - GENERAL**

**1.1 DESCRIPTION OF WORK**

- A. Work Included: This Section specifies modular tactile surface tiles at station platforms.
  - 1. This Section includes Specifications for furnishing and installing composite wet set replaceable tactile warning surface (TWS) Units, in an in-line truncated dome pattern, embedded in all BRT station concrete platforms, curb ramps and walking surfaces at the locations and to the dimensions shown on the Drawings, in accordance with the Contract Documents and as directed by the Engineer.
  - 2. It is the responsibility of the Contractor to provide coordination between modular tactile surface manufacturer and concrete platform contractor to ensure compatibility of the two systems.
- B. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
  - 1. MassDOT Section 901 – CEMENT CONCRETE MASONRY
  - 2. Section 03300 – CAST-IN-PLACE CONCRETE
  - 3. Section 07920 – JOINT SELANTS

**1.2 SUBMITTALS**

- A. Shop Drawings: Include complete layout and fabrication details, composite structure, dimensions of tiled areas, and affected adjacent areas. Provide large scale plan details of the tiles at the curves, including fastener locations. Shop Drawings shall also show all pertinent characteristics of the composite wet set replaceable tactile warning surface unit, including profile, sound on cane contact amplification feature and installation methods.
- B. Product Data: Manufacturer's catalog cuts, material specifications, installation and maintenance instructions, and other data pertinent to the work of this Section.
- C. Samples: One full-size sample of the type, size, pattern, and color of tile required, and five twelve inch by twelve inch samples for MBTA records. Samples shall be properly labeled and shall contain the following information: Name of Project, Submitted by, Date of Submittal, Manufacturer's Name, and Catalog No.
- D. Material Certification: Manufacturer's certification that all products meet specified requirements, as verified by a certified independent testing agency. Submit certified test reports for all tests shown in Article 2.02 B, indicating for each test whether or not the tile passes or fails the passing criteria. Test report shall be current and shall not predate the notice to proceed date of this contract by more than two years. All test reports submitted shall be representative of the tactile warning surface product delivered to the Project, and shall be no more than three (3) years old from the time of the submittal.

- E. Installer Certification: Manufacturer's approval of installer if other than manufacturer, and detailed work history with the product proposed for installation.
- F. Extra Materials: After completion of the work, furnish a minimum of ten percent of the total amount of tile furnished, from the same manufactured lot as materials furnished for work of this Section, in sealed, protective packaging marked with Contract number, lot number and identification contents. Store in a location designated by the Engineer.

### 1.3 QUALITY ASSURANCE

- A. Manufacturer: A company specializing in the manufacture of modular tactile surface tiles as used in transit systems for guidance of the sight impaired. Provide composite wet set replaceable tactile warning surface units as produced by a single manufacturer.
- B. Installation: Composite wet set replaceable tactile warning surface units shall be installed at the precast concrete platform panel precast shop at the time of casting.
  - 1. All composite wet set replaceable tactile warning surface units shall be cast integrally with concrete platforms flush with the finished surface of the platform under the supervision of a manufacturer-approved installer with documented experience in work similar to that of this Section.
  - 2. The manufacturer-approved installation supervisor must be approved by the Engineer before installation of the tile may begin.
  - 3. All anchorages of composite wet set replaceable tactile warning surface units shall be fully embedded into concrete.
  - 4. Composite wet set replaceable tactile warning surface units shall be suspended as part of the casting process to ensure that full bond of anchorages occurs. Composite wet set replaceable tactile warning surface units shall not be "pressed" into wet concrete.
- C. Hold Point - Mock-Up: After approval of materials, erect an eight foot long tile mock-up using specified materials, at a location acceptable to the Engineer.
  - 1. Assign the same construction crew to both the mock-up and the permanent work.
  - 2. If not approved, remove and replace mock-up at no additional cost to the Authority. Repeat procedure until approval is granted.
  - 3. Approved mock-up shall serve as the quality standard for appearance, tolerances, and workmanship.
  - 4. Approved mock-up may be incorporated in the permanent work, with the following certification.
  - 5. Protect and maintain approved mock-up in accepted condition throughout the construction period. When no longer required, remove and dispose of off site, if not incorporated into the permanent work.
- D. Tactile warning surface product shall meet or exceed the following test criteria using the most current test methods:
  - 1. Water Absorption: Not to exceed 0.20%, when tested in accordance with ASTM-D570.
  - 2. Slip Resistance: 0.80 minimum combined wet/dry static coefficient of friction when tested in accordance with ASTM C 1028.

3. Compressive Strength: 25,000 psi minimum, when tested in accordance with ASTM D695.
4. Tensile Strength: 10,000 psi minimum, when tested in accordance with ASTM D638.
5. Flexural Strength: 25,000 psi minimum, when tested in accordance with ASTM D790.
6. Chemical Stain Resistance: No reaction to 1% hydrochloric acid, motor oil, calcium chloride, gum, soap solution, bleach, and antifreeze, when tested in accordance with ASTM D543 or D1308.
7. Abrasion Resistance: 300 minimum, when tested in accordance with ASTM C501.
8. Flame Spread: 25 maximum, when tested in accordance with ASTM E84.
9. Accelerated Weathering of Tactile Warning Surface when tested by ASTM-G155 or ASTM G151 shall exhibit the following result:  $\Delta E < 5.0$  at 2,000 hours minimum exposure.
10. AASHTO-H20 Load Bearing Test: No Damage at 16,000 # loading.
11. Salt and Spray Performance of Tactile Warning Surface: No deterioration or other defects after 200 hours of exposure, when tested in accordance with ASTM-B117.

#### **1.4 DELIVERY, STORAGE AND HANDLING**

- A. Composite wet set replaceable tactile warning surface units shall be suitably packaged or crated to prevent damage in shipment or handling. Finished surfaces shall be protected by sturdy wrappings.
- B. Deliver materials and products in unopened, factory labeled packages. Store and handle in strict compliance with manufacturer's instructions and recommendations. Store under cover and protect from all damage and pilferage

#### **1.5 WARRANTY**

- A. In addition to the requirements of the General Conditions, composite wet set replaceable tactile warning surface units shall be guaranteed in writing for a period of five (5) years from date of Contract's final completion. The guarantee includes defective work, breakage, deformation, and loosening of tactile warning surface material. The TWS manufacturer shall also warrant and certify that the reverse profile of the TWS Unit will not change in any way for a minimum of 10 years to insure full TWS Product interchangeability

## **PART 2 - PRODUCTS**

### **2.1 GENERAL**

- A. The modular tactile surface shall differ from adjoining surfaces in resiliency or sound-on-cane contact as set forth in the following accessibility guidelines. These references are intended to establish quality and performance characteristics and meet the legal definition of the law.
1. 28 CFR Part 36 – Appendix A: Standards for Accessible Design ADA Accessibility Guidelines for Buildings and Facilities (latest edition).
  2. Massachusetts Architectural Access Board Rules and regulations (521 CMR) (latest edition).
  3. Accessibility Handbook for Transit Facilities – USDOT (FTA-MA-06-0200-92-1) (DOT-VNTSC-FTA-92-4) (July 1992).
  4. Commuter Rail Design Standards Manual – VOL 1, SEC 1: Track and Roadway, MBTA Railroad Operations (Rev No. 1 19 April 1996).
  5. Massachusetts State Building Code (Current Edition).
  6. In case of conflict between codes, standards, regulations, specifications, general notes and/or manufacturer's requirements, use the more stringent provisions.

### **2.2 MODULAR TACTILE SURFACE TILE**

- A. Accessibility Requirements: The modular tactile tile surface system shall differ from adjoining surfaces in resiliency or sound-on-cane contact as set forth by the latest requirements of the Americans with Disabilities (ADA) and the Massachusetts Architectural Access Board (AAB). Such reference is intended to establish quality and performance characteristics and meet the legal definition of the law.
- B. Modular Tile: Provide fiberglass polymer platform edge surfaces with 24 in. x 48 in. sheets, as indicated on Drawings.
- C. Composition: Composite wet set replaceable tactile warning surface units shall be manufactured using a matte finish exterior grade homogeneous (uniform throughout thickness of product) glass and carbon reinforced polyester based SMC composite material. Truncated domes must contain fiberglass reinforcement within the truncated dome for superior structural integrity and impact resistance. A matte finish will be required on the tactile warning surface for superior slip resistance performance superior to that offered by a gloss finish. Use of tactile warning surface products employing coatings or featuring layers of material with differing composition, performance, or color properties is expressly prohibited under this Section.
- D. Color: Color shall be homogeneous throughout the composite wet set replaceable tactile warning surface units and shall be Federal Yellow per Federal Standard 595B Table IV, Color No. 33538.
- E. Domes: Square grid pattern of raised truncated domes of 0.2 inches nominal height, base diameter of 0.9 inches, and top diameter of 0.45 inches. The Federal Code of Regulations permits a truncated dome spacing range of 1.6”-2.4.” For superior wheelchair, walker and shopping cart mobility, truncated domes shall have a center-to-center (horizontally and

vertically) spacing of 2.35 inches, measured between the most adjacent domes on square grid.

- F. Configuration: Composite wet set replaceable tactile warning surface unit sizes shall be as indicated on the Contract Drawings. Replaceable tactile warning surface units shall feature a minimum of four (4) embedded corrosion resistant 1.50-inch zinc inserts with ½-inch diameter Stainless Steel fasteners, Fasteners must be covered with a structural water tight cap. Fasteners must be located BETWEEN the truncated domes (in the field) for maximum protection of the fastener integrity. Fasteners are NOT to be located in the truncated dome.
  - 1. The field area shall consist of a non-slip textured surface with a minimum static coefficient of friction of 0.80, wet and dry.
  - 2. At a minimum, tactile warning surface product thickness shall measure 3/8" (nominal) exclusive of the perimeter 5/8" thick by 1" wide flange structure. The body of the TWS Unit must consist of a SOLID body for maximum strength and to eliminate the possibility of air entrapment and cracking. "Hollow back," "honeycomb," or "waffle tiles" are not acceptable for use on this Project.
- G. Cleaning materials used on site shall have code acceptable low VOC solvent content and low flammability.
- H. The Specifications of the concrete, sealants and related materials shall be in accordance with the Contract Documents and the guidelines set by their respective manufacturers.

## **PART 3 - EXECUTION**

### **3.1 INSPECTION OF SURFACES**

- A. Carefully inspect tactile supporting devices for conditions affecting application and performance of the work of this Section. Report defects in writing to Engineer. Do not proceed with tactile tile installation work until unsatisfactory conditions have been corrected.
- B. Beginning work shall constitute acceptance of its conditions and any defects in tactile tile installation work resulting from such accepted application shall be corrected without further expense to the Authority.

### **3.2 PREPARATION**

- A. Coordinate tile installation, working with prior and subsequent work of other trades.
- B. During all concrete pouring and tactile warning surface product installation procedures, ensure adequate safety guidelines are in place and that they are in accordance with the applicable industry and government standards.
- C. The physical characteristics of the concrete shall be consistent with the Contract Specifications while maintaining a slump range of 4 - 7 to permit solid placement of the composite WET SET "Replaceable" tactile warning surface unit. An overly wet mix will cause the composite WET SET "Replaceable" tactile warning surface unit to float. Under

these conditions suitable weights such as 2 concrete blocks or sandbags (25 pounds) shall be placed on each tactile warning surface unit.

- D. The concrete shall be poured and finished, true and smooth to the required dimensions and slope prior to tactile warning surface unit placement.

### **3.3 INSTALLATION (PLATFORMS)**

- A. Install tile in accordance with manufacturer's recommendations and as indicated on the Drawings and as shown on approved shop drawings.
  - 1. All composite wet set replaceable tactile warning surface units shall be cast integrally with concrete platforms flush with the finished surface of the platform under the supervision of a manufacturer-approved installer with documented experience in work similar to that of this Section.
  - 2. All anchorages of composite wet set replaceable tactile warning surface units shall be fully embedded into concrete.
  - 3. Composite wet set replaceable tactile warning surface units shall be suspended as part of the process to ensure that full bond of anchorages occurs. Composite wet set replaceable tactile warning surface units shall not be "pressed" into wet concrete.
- B. Hold Point - The tiles shall be dry-fit and approved by the Engineer, prior to installation to ensure proper installation.
- C. Minimize trimming by using whole tiles to the greatest extent possible. Any domes cut in trimming shall be beveled and polished.
- D. At the platform radius, tiles shall be installed with the platform edge tangent to the radius with the ends trimmed to provide a joint tangent to the curve and square to adjoining tiles. Domes cut in the trimming shall be beveled and polished to match the finish of the tile.
- E. The Installer shall leave a 1/8" nominal gap between successive Tactile Warning Surface Units. As part of the concrete finishing operation, the Installer shall apply 1/4" edge treatment around the perimeter of the Tactile Warning Surface Units to facilitate future replacement of the Tactile Warning Surface Unit. A Urethane Sealant such as Sikaflex 1a or BASF Sonneborn NP1 shall be applied to the edge treatment for a watertight Tactile Warning Surface Unit installation.
- F. When multiple tactile warning surface units regardless of size are used, the truncated domes shall be aligned between the tactile warning surface units and throughout the entire tactile warning surface installation.
- G. Tactile warning surface unit shall flush to the adjacent concrete surface or as the Drawings indicate to permit proper water drainage and eliminate tripping hazards between adjacent finishes.
- H. Apply sealant only at expansion joints in accordance with Section 07920 - JOINT SEALANTS.



I. Fasteners, as required by the platform conditions, shall be used to fully fasten the tile to the platform to provide complete contact between the tile and the platform.

### **3.4 INSTALLATION (CURB RAMPS)**

- A. Contractor will not be allowed to install Tactile Warning Surface Product until all submittals have been reviewed and approved by the Engineer.
- B. Tactile warning surface product shall be installed per manufacturer's instructions.
- C. To the maximum extent possible, the tactile warning surface units shall be oriented such that the rows of in-line truncated domes are parallel with the direction of the ramp. When multiple tactile warning surface units regardless of size are used, the truncated domes shall be aligned between the tactile warning surface units and throughout the entire tactile warning surface installation.
- D. In accordance with the Revised Draft Guidelines for Accessible Public Rights of Way (11/23/05) Sections R221, R303.3.4, R304.2, tactile warning surface product shall be located so that the edge nearest the curb line is 6" minimum and 8" maximum from the curb line. This allows wheelchair users to gain momentum before traveling over the truncated domes and it provides visually impaired pedestrians additional time to react to the tactile warning surface or advanced warning before they reach the street.
- E. The tactile warning surface units shall be tamped or vibrated into the fresh concrete to ensure that there are no voids or air pockets, and the field level of the tactile warning surface unit is flush to the adjacent concrete surface or as the Drawings indicate to permit proper water drainage and eliminate tripping hazards between adjacent finishes.

### **3.5 CLEANING AND PROTECTION**

- A. During construction and prior to opening the platform edge for public use, cover all tactile surfaces with an appropriate covering material, temporarily secured in place, to protect it from damage from construction activity. Remove covering when protection is no longer needed and dispose of it off-site in a manner conforming to all appropriate laws and regulations.
- B. Protect tactile warning surface unit against damage during construction period to comply with tactile warning surface unit manufacturer's Specifications.
- C. During and after the tactile warning surface unit installation and the concrete curing stage, it is imperative that there are no walking, leaning or external forces placed on the tactile warning surface unit to rock the tactile warning surface unit, causing a void between the underside of the tactile warning surface unit and the concrete substrate.
- D. Prohibit construction vehicle traffic from riding on newly tiled surfaces. Do not place or store construction equipment or tools directly on tiled surfaces.
- E. Provide snow removal as required using equipment that will not damage tile.
- F. If requested by the Project Manager, clean tactile warning surface units not more than four (4) days prior to date scheduled for inspection intended to establish date of

substantial completion in each area of project. Clean tactile warning surface unit by method specified by tactile warning surface manufacturer.

#### **PART 4 - MEASUREMENT AND PAYMENT**

##### **4.1 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Station. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of all modular tactile surfaces for the BRT Stations.
- B. Separate measurement and payment will not be made for modular tactile surfaces to be placed within wheelchair ramps, but all costs in connection therefore shall be included in the Contract Unit price for Item No. 701.2 – Cement Concrete Wheelchair Ramp.

**END OF SECTION**

## **SECTION 09861**

### **ANTI-GRAFFITI COATINGS**

#### **PART 1- GENERAL**

##### **1.1 DESCRIPTION**

- A. This Section provides a technical strategy for installation of specified anti-graffiti (AG) coatings on exposed structural substrates on fixed property and in rights-of way under the purview of MBTA.
- B. The basic technical concept involves installing protective coatings to prevent permanent marking of surfaces via convenient removal of graffiti markings on a repeated basis. Coatings with non-wetting or other physico-chemically properties that discourage graffiti marking may warrant preferred selection.
- C. Affected substrates include: Vertical, sloped, curved and horizontal concrete at canopies.
- Bare and painted concrete, concrete block and brick masonry.
  - Bare, painted and vinyl-coated aluminum (mostly signage), bare stainless steel, bare and painted sheet metal, including galvanized sheet.
  - Clear, tinted and painted plastic panes and panels, including acrylic (e.g., Plexiglass), polycarbonate (e.g., Lexan) and fiberglass-reinforced plastic (FRP) sheet.
  - Bullet-proof and other glass.
- D. At the discretion of the MBTA Engineer, the anti-graffiti coating shall be a clear material that does not significantly alter the appearance of the substrate.

##### **1.2 DESIGN GUIDANCE**

- A. Surface texture:

Surface cleanability depends on roughness and porosity. Architectural surface textures range from super-smooth glaze finishes on tiles and glass to coarsely fractured concrete block. Porosity of the surfaces also ranges from zero for glass and metal to significant for concrete and masonry.

Rough surfaces should get an AG coating that permanently seals surface porosity. Conversely, smooth surfaces may need to be roughened/profiled in a controlled manner in order for the AG coating to bond adequately to the surface.

- B. Recoating:

The number of times a coated surface can be cleaned before it is recoated depends on the coating durability and the cleaning procedure. Cleaning procedures should follow the coating manufacturer's instructions unless these are superseded by specific MBTA Engineer's instructions for that specific AG coated surface.

Coatings for specific surfaces should be selected with an approximate expected number of cleaning cycles to recoat in mind, depending on such factors as work location and accessibility,

surface preparation requirements for recoating, and other coating application considerations, including compatibility and adhesion between the old and new AG coatings.

C. New construction:

Anti-graffiti measures should be an architectural design consideration in selecting materials and surface textures. At a minimum, graffiti-susceptible surfaces should be amenable to sealing with a clear or pigmented AG coating, or incorporate other anti-graffiti measures approved by the MBTA Engineer.

### **1.3 CERTIFICATION AND REGULATIONS**

A. Contractor certification:

Contractors installing anti-graffiti coatings shall be certified in writing by the manufacturer as a trained installer of the specified coating materials.

B. Handling, storing, disposal, and installation of coating materials and solvents: Contractor is responsible for fully meeting health, occupational safety and environmental requirements of all applicable local, state, or federal codes, regulations, and ordinances. Contractor shall ascertain what local, state and federal codes, regulations, and ordinances are in effect.

C. To ensure full product compatibility, primary materials for each coating system installed in accordance with this Section shall be sourced from a single manufacturer. Secondary materials and solvents from other sources shall be approved by the coating system manufacturer.

D. Coating materials shall meet Federal and State requirements for Volatile Organic Compound (VOC) content.

### **1.4 SUBMITTALS**

A. Product Data Sheets:

Coating manufacturer's product data sheets, including installation instructions and service limitations for each material used shall be submitted to the MBTA Project Engineer.

B. Certified test reports shall be provided for all specified coating performance test claims.

C. Performance test reports:

Submit evidence the AG coating has successfully performed or been field-tested for AG purposes for a minimum of six months. Longer performance and testing shall work in the coating's favor. Descriptions of test conditions and performance criteria shall be sufficiently detailed for results to be comparatively evaluated by the MBTA Engineer and for testing to be repeated by others.

### **1.5 PRODUCT STORAGE, HANDLING AND DISPOSAL**

A. Deliver materials and products in sealed, factory-labeled containers.

B. Store the materials in a safe place that cannot be accessed by unauthorized people.

- C. Store, handle and prepare all coating materials under cover and protect from weather damage, strictly complying with the product manufacturer's directions and temperature limits.
- D. Collected, package and dispose of spoiled, unused and waste materials and product debris in total compliance with MBTA rules for chemical and solvent disposal.

## **1.6 INSTALLATION WORK RESTRICTIONS**

### **A. Weather:**

Perform anti-graffiti coating installation work, including surface preparation and curing, only when ambient weather conditions definitely will remain within temperature and humidity limits specified by the coating manufacturer.

### **B. Temperature:**

1. Unless otherwise approved by the product manufacturer, apply the coating materials only when substrate surface and ambient temperatures are between 50°F - 85°F and will not be out of this range during the entire work period.
2. Unless otherwise approved by the product manufacturer, store base materials and mixed products between 60°F and 80°F during application.
3. Do not apply materials that are hotter than permitted by the product manufacturer.

### **C. Schedule coating installation work to avoid interference between construction work, surface preparation and to minimize exposure of pedestrian and auto traffic.**

### **D. Spills and overspray:**

1. Deliberately avoid overspray on nearby surfaces and public property.
2. Divert and protect pedestrian and auto traffic that could be affected by inhalation and overspray exposure during coating preparation and installation. Remove misapplied material, spills and overspray immediately.

### **E. Personnel safety:**

1. Contractor employees installing the coating shall fully comply with all applicable personnel safety and health rules and procedures (see 1.02 B) and with the coating manufacturer's health and safety directions and recommendations.
2. Do not use flammable products near fire or extreme heat.
3. Always work in adequately ventilated conditions. Applicators shall wear NIOSH/MSHA approved respirators, eye protection, and protective clothing. Read material safety data sheets for additional toxicity and product hazard information.
4. The public and all people not employed by the Contractor and MBTA shall be adequately protected from inhalation and overspray exposure to the coating materials.

## **PART 2 - MATERIALS**

### **2.1 COATINGS**

- A. Anti-Graffiti Coating for Concrete: Clear TNEMEC V626 Dur A Pell GS, 2 coats at coverage rate of 200 sq.ft./gallon.

### **2.2 CLEANING SOLUTIONS**

- A. Cleaning solutions shall be as approved or recommended by the AG coating manufacturer to maximize cleaning effect without harming the AG coating.
- B. Cleaning solutions and procedures shall not damage the substrate beneath the AG coating except where this is approved by the MBTA Engineer (e.g., because the substrate will be newly coated.)
- C. Cleaning solutions shall meet MBTA requirements for personnel exposure, safe handling and disposal.

## **PART 3 - EXECUTION**

### **3.1 WORK AREA SUBSTRATE INSPECTION**

- A. Examine substrates and identify conditions that could impede successful and smooth execution of the work. Factors to consider:
  - Type of surface, including texture and porosity – influences surface preparation and coating system selection.
  - Time windows and worker access for required sequence of surface preparation, coating installation (number of coats); curing.
  - Potential effects of changes in ambient conditions in the work area and dryness of the substrate.
  - Health and safety protection requirements for Contractor and public.

Do not start work until job conditions are satisfactory to complete all required tasks in the available time.

### **3.2 COATING SELECTION**

- A. Protected substrates shall be adequately sealed and non-porous before the anti-graffiti coating is applied.
- B. To select the right anti-graffiti product, the MBTA Engineer shall adequately weigh the following criteria:
  - Selection for simpler application with fewer chemical exposure concerns from solvents favors organo-silicate types.
  - Selection for superior adhesion to non-blasted glass, plastic, previously painted and less than ideal substrates favors polyurethane types.
  - Selection for higher hardness to resist repeat cleaning performance favors organo-silicate types.

- Selection for longer gloss retention in UV exposure favors polyurethane types.
  - Highest anti-graffiti performance is obtained by applying an additional, clear polyurethane seal coat.
- C. In general, clear coating shall be used to preserve architectural/aesthetic surface appearance, as directed by the MBTA Engineer.

### **3.3 APPLICATION**

A. General Application procedures:

Strictly follow the coating manufacturer's surface preparation, application and curing instructions, unless more restrictive requirements are specified in this Section. The coating manufacturer's limits for thinning, additives, pot-life, wet film thickness per coat and recoat time shall be known and carefully followed.

B. Masking and overspray protection:

Protect contingent surfaces that should not be coated, oversprayed or contacted by cleaning or coating chemicals. Normally this is done with strippable masking materials, plastic sheeting and waterproof tape, or masking materials barriers approved by the MBTA Engineer.

C. Surface Preparation:

The substrate shall be flat and smooth enough to be thoroughly prepared and for the coating material to be evenly applied everywhere. NOTE: Coarsely profiled substrates like fractured concrete block require extra measures to benefits from anti-graffiti coatings.

1. Cavities and protuberances that can cause shadowing shall be filled or removed. Substrate roughness shall allow the method of application (brush, roller or spray) to provide uniform film thickness everywhere.
2. Materials used to clean, patch, caulk and fill the substrate shall be approved by the coating manufacturer. Compatibility of existing materials shall be patch-tested before the coating is applied or painted with a primer or tie-coat from the coating manufacturer.
3. The surface shall be thoroughly cleaned, dust-free, with no dirt, loose material, oil, water and other residues or contaminants.
4. Masonry, tile and concrete surfaces shall be power-washed with high pressure water and appropriate chemical additives to remove surface contamination.
5. Visible moisture is not permitted. Dampness shall not exceed the coating manufacturer's limits.
6. Existing coatings must be tightly adhered and proven by test to be unaffected by the new coating.

D. Sample preparation:

At the MBTA Engineer's discretion, the Contractor shall provide portable, finished samples of the final product on the target substrate(s) that are prepared in the specified manner. The resulting samples shall be used for comparative acceptance of actual work at the MBTA Engineer's discretion.

### **3.4 FIELD QUALITY CONTROL**

- A. The Contractor shall establish and maintain throughout the work of this Section effective quality control measures described in a written scheme to ensure that all coating related work is performed as required by the Contract Documents.
- B. Quality-related test and inspection procedures, acceptance criteria and test reporting requirements for all phases of coating installation shall be defined by the MBTA Engineer before the work commences.

### **3.5 GRAFFITI REMOVAL**

- A. Main objectives in removing graffiti from surfaces protected with AG coatings installed as described in this Section shall be to use experience and engineering judgment of all parties – MBTA, Contractor and AG coating manufacturer to:
  - Minimize the physical and chemical harshness of the cleaning procedure so as to minimize environmental and health effects and preserve as much of the AG coating as practical during the cleaning operation.
  - Clean with water, including hydro-blasting up to 5,000psi, wherever possible. Increase the solvent power of water by adding low concentrations of detergent or non-toxic emulsifier, such as tri-sodium phosphate (TSP), sodium carbonate (soda ash) or approved proprietary cleaning surfactants.
  - Use only commercial organic solvent cleaners specified by the AG coating manufacturer for their specific coatings. These must contain non-toxic, biodegradable chemicals that do not require special containment and disposal.
- B. Use an escalating scale of more aggressive cleaning procedures on a systematic basis, using test cleaning to select the cleaning procedure.
- C. Carefully follow recoat time limits if new AG coating material is applied to surfaces freshly cleaned with solvent cleaners.
- D. Keep a complete log of cleaning events and procedures used to remove graffiti on every project doing work in accordance with this Section.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 GENERAL**

- B. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of all anti-graffiti coatings for the BRT Stations.

### **END OF SECTION**



## **SECTION 10100**

### **DISPLAY CASES**

#### **PART 1 - GENERAL**

##### **1.1 DESCRIPTION OF WORK**

- A. Work Included: This Section specifies all display cases as indicated on the Drawings and specified herein.
- B. Transportation: Deliver all display cases and related elements, including mounting hardware, to the job site.
- C. Temporary: Provide fabrication, erection, and removal of any and all temporary safety barricades, temporary holding, retaining or storage structures necessary as described herein.

##### **1.2 PERFORMANCE REQUIREMENTS**

- A. Design Criteria: Design, fabricate, and install display cases to withstand normal exposure to weather, temperature variation, wind loads and building movement; provide units resistant to vandalism and theft.
- B. Field Measurements: Check actual locations of construction - to which metal fabrications must fit - by accurate field measurements before fabrication; show recorded measurements on final shop drawings.
- C. Thermal Movements: Allow for thermal movement resulting from the following maximum change (range) in ambient temperature in engineering, fabricating, and installing cases to prevent buckling, opening of joints, over stressing of components and connections, and other detrimental effects. Base engineering calculation on actual surface temperatures of materials due to both solar heat gain and nighttime sky heat loss.
  - 1. Temperature Change (Range): 0 - 180 deg F ambient, material surfaces.
- D. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

##### **1.3 SUBMITTALS**

- A. All submittals shall be provided to the Architect and MBTA Design and Construction Department for review; disposition and documentation management will be provided by the MBTA Design and Construction Department.
- B. Product Data: Manufacturer's product data, any limitations and recommendations for each material used, installation instructions, and manufacturer's certification (stating that materials comply with requirements) for the Architect and MBTA Design and Construction Department's review and approval.

1. Include material details for each display case specified.
- C. Shop Drawings: Submit shop drawings showing layout, profiles, and product components, including dimensions, anchorage, all details, plans and sections required to indicate all conditions. Provide four copies of shop drawings for action by the Architect and MBTA Design and Construction Department. After action provide two copies of shop drawings on which action has been taken to the Architect and MBTA Design and Construction Department for Architect and MBTA Design and Construction Department's records.
  - D. Reuse of Existing Sign Frames: For reuse of existing sign frames at existing stations, verify rough opening of all dimensions and fill in on schedule column labeled: "Verification". Advise the MBTA Design and Construction Department of any discrepancies between design size and field-verified size.
  - E. Samples for Approval: Submit suppliers standard color chart for selection purposes and selected colors to the Architect and MBTA Design and Construction Department for verification purposes.

#### **1.4 QUALITY ASSURANCE**

- A. Reference Standards: The work shall conform to the codes and standards of the following regulatory Agencies and Authorities as further cited herein:
  1. ADAAG: Americans with Disabilities Act Accessibility Guidelines
  2. ANSI: American National Standards Institute.
  3. ASTM: American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103 as published in "Compilation of ASTM Standards in Building Codes".
  4. MAAB: Massachusetts Architectural Access Board.
- B. Source: Obtain all products in this section from a single supplier.
- C. Qualifications: The approved manufacturer shall have a minimum of 5 years of successful experience with similar work, and shall have a reputation for doing satisfactory work on time.
- D. Engineering: The Contractor is responsible for the proper engineering of all items. The internal structure, dimensions and specifications for all items shall be indicated in the Contractor's shop drawings. Contractor to engineer display cases to proper level to withstand abuses of their environment.
- E. Coordination: The work in this Section shall be completely coordinated with the work of other Sections. Verify dimensions and work of other trades that adjoin materials of this Section before the installation of items herein specified. Cooperate with such trades to assure the steady progress of all work under this Contract.
- F. Project Meetings: Subcontractors shall be required to attend project meetings at the Project site when required by the Architect and MBTA Design and Construction Department.
- G. Certification: Submit manufacturer's certification that materials furnished comply with requirements specified.

- H. Maintenance Instructions: Submit manufacturer's printed instructions for maintenance of each display case installed to the MBTA, including precautions for use of cleaning materials.
- I. Warranty:
  - 1. Submit a written Manufacturer's warranty for MBTA acceptance, signed by the manufacturer, agreeing to repair or replace display cases that fail due to defects in material or workmanship during the specified warranty period.
  - 2. Warranty Period: 1 Year Limited

## **1.5 DELIVERY, STORAGE AND HANDLING**

- A. Installer: Installer specialized and experienced in work similar to that required for this project shall perform Installation.
- B. Deliver work under this Section to the site in ample time to avoid delay in job progress and at such times as to permit proper coordination of the various parts.
- C. Installation of this work shall be scheduled to occur near time of Substantial Completion.

## **1.6 PROJECT CONDITIONS**

- A. Inspection of Site: The Contractor shall visit the site of the proposed work and become fully acquainted with existing conditions, and to become fully informed as to the facilities involved and the difficulties and restrictions attending the performance of the Contract, prior to submitting a price quotation.
- B. Substrates: Proceed with work of this Section only when substrate construction and penetration work have been completed.

# **PART 2 - PRODUCTS**

## **2.1 ACCEPTABLE MANUFACTURERS**

- A. Specifications based on "SCPXL" Outdoor Poster Cases manufactured by Access Display Group, Inc. 800-289-1539, Freeport, NY 11520. Manufacturers products must meet or exceed the specifications approved for use on the project. Provide products of one of the following vendors or approved equal:
  - 1. Access Display Group
  - 2. SwingFrame
  - 3. Outdoor Display Cases

## **2.2 MATERIALS**

- A. Materials
  - 1. Aluminum Extrusions: Meeting ASTM B221, alloy 6063-T6.
  - 2. Aluminum Panels: Meeting ASTM B209, minimum 0.032" thick.

## 2.3 FABRICATION

### A. General:

1. Comply with requirements indicated for materials, thickness, finishes, colors, designs, shapes, sizes and details of construction.
2. Welded Connections: Comply with AWS standards for recommended practices in shop welding. Provide welds behind finished surfaces with distortion or discoloration of exposed side. Clear exposed welded surfaces of welding flux and dress on exposed and contact surfaces.
3. Mill joints to a tight, hairline fit.
4. Pre-assemble display cases in the shop. No visible fasteners.
5. Form panels to required size and shape. Comply with requirements indicated for design, dimensions, finish, color and details of construction.
6. Display cases to be fabricated based on dimensions as shown on Drawings.
7. Coordinated dimensions and attachment methods to produce display panels with closely fitting joints. Align edges and surfaces with one another in the relationship indicated.
8. Increase metal thickness or reinforce with concealed stiffeners or backing materials as required to produce surfaces without distortion, buckles, warp or other surface deformations.
  - a. Fabricate frame from extruded aluminum. Corners to have hairline miters and be braced by means of internal aluminum angels. If welding is necessary, none should be visible. Frames shall have a continuous back-up member behind door.
  - b. Venting: Provide venting as recommended by the manufacturer to prevent condensation.

### B. Display Case Construction:

1. Casing: Aluminum extrusion mitered and reinforced with locking corner brackets.
2. Exterior Backing: 0.032" weather resistant aluminum with silicone sealant.
3. Interior Backing: 1/32" cork laminated to 7/16" fiberboard.
4. Weep Holes: on bottom.
5. Lock: security cam lock.

### C. Finishes:

1. Aluminum with anodized finish: Black.
2. Aluminum with a satin polyurethane coating. Faces shall be smooth, free of scratches, blemishes or other imperfections.

### D. Door Profile:

1. Hinged aluminum extruded door, mitered and assembled with concealed corner angles, 1/4" shatter resistant acrylic window, and cam lock.

### E. Background:

1. Vinyl (grey) over Cork/Fiberboard.

### F. Mounting:

1. Sign Frame Mounting: Mount display case to sign frame structure through case sides.
  - a. Maintain a minimum 3/16" open joint to allow for venting.

## **PART 3 - EXECUTION**

### **3.1 INSPECTION**

- A. The Installer shall examine substrates, supports, and conditions under which this work is to be performed, and notify the Contractor and the Architect in writing of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning work means Installer accepts substrates and conditions.
- B. Notification Point : Architect and MBTA Design and Construction Department will be given 72 hour notice to perform field inspection at the start of installation. If work does not meet project requirements, contractor must remove and replace deficient work.

### **3.2 INSTALLATION/APPLICATION/ERECTION**

- A. All locations where display cases are to be installed new or retrofitted to existing frames must be field measured by contractor. This must be documented and sent to the Architect and MBTA Design and Construction Department.
- B. Strictly comply with approved shop drawings and manufacturer's instructions and recommendations, except where more restrictive requirements are specified in this Section.
- C. Install work plumb, level, and in true plane and alignment and at heights indicated in accordance with manufacturer's recommendations.
- D. Install products at heights to conform to Americans with Disabilities Act Accessibility Guidelines (ADAAG) and applicable local amendments and regulations.
- E. Follow manufacturer's instructions for storage and handling of units before installation.
- F. Protect adjacent or adjoining surfaces and work from damage during installation in this Section.
- G. Work shall be designed and anchored so that work will not be distorted nor the fasteners overstressed from expansion and contraction of metal or other materials as applicable.

### **3.3 CLEANING AND PROTECTION**

- A. Touch-up damaged finishes and eliminate any evidence of repair. Clean exposed surfaces using materials and methods recommended by manufacturer of material or product being cleaned. Remove and replace work that cannot be successfully repaired or cleaned.
- B. Provide temporary protection to ensure work is delivered without damage or deterioration at time of final acceptance. Remove protections and reclean as necessary immediately before final acceptance.
- C. Manufacturer shall provide Authority with information on cleaning and maintenance recommendations for all display cases.

- D. Names, stamps and decals of manufacturers, installers or maintainers of display cases shall not be visible in the finished work.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of all display cases at the BRT Stations.

**END OF SECTION**

## **SECTION 10400**

### **FIXED SIGNAGE**

#### **PART 1 - GENERAL**

##### **1.1 DESCRIPTION OF WORK**

- A. Work Included: This Section specifies all fixed signage at the MBTA Bus Rapid Transit (BRT) Stations as indicated on the Drawings and specified herein. The work of this section includes, but is not limited to, the fabrication and installation of the following:
  - 1. Station Identification and Wayfinding signs as indicated – porcelain enamel on steel
  - 2. Sign frames and mounting accessories as indicated and required
- B. SIGNmaker™ software application: To be used by the MBTA Design and Construction Department for generating all custom sign content as digital files. No other method of creating graphic files or content is permitted.
- C. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
  - 1. Section 05500 – MISCELLANEOUS METALS
  - 2. Section 10100 – DISPLAY CASES
  - 3. Section 10426 – TACTILE /BRAILLE SIGNAGE
  - 4. Section 16000 – ELECTRICAL - “Exit” signs; and “Variable Message Signs”.
- D. Transportation: Deliver all signs and related elements, including frames and mounting hardware, to the job site.
- E. Temporary: Provide fabrication, erection, and removal of any and all temporary safety barricades, temporary holding, retaining or storage structures necessary as described herein
- F. Permits: Obtain permits required by Local Authorities for installation of signs.

##### **1.2 GRAPHICS**

- A. SIGNmaker™ Digital Graphics files: The MBTA Design and Construction Department will prepare and supply all digital sign content using the SIGNmaker™ software application. This application will provide ½” scale elevation drawings of every sign for contractor use in preparing shop drawings; it will also provide full size sign layouts for direct fabrication from the digitally provided files. The contractor is responsible for verifying that each sign frame and sign panel is coordinated with the dimensions and content of supplied digital sign files; and for fabricating and installing all signs based on the MBTA Design and Construction Department’s supplied graphic layouts of signs, maps and associated panels.
- B. Murals and Art work panels are provided by the MBTA Design and Construction Department.

### **1.3 PERFORMANCE REQUIREMENTS**

1. Design Criteria: Design, fabricate, and install sign items to withstand normal exposure to weather, temperature variation, wind loads and building movement; provide units resistant to vandalism and theft.
2. Field Measurements: Check actual locations of construction - to which metal fabrications must fit - by accurate field measurements before fabrication; show recorded measurements on final shop drawings.
3. The drawings indicate minimum dimensions and thicknesses for components. Where performance requirements necessitate thickness of material to be increased or additional reinforcing to be added such revisions shall be made without changing the visible profiles of in-lay elements. Where changes cannot be made without changing visible profiles they shall be made only with approval by the MBTA Design and Construction Department.
4. Thermal Movements: Allow for thermal movement resulting from the following maximum change (range) in ambient temperature in engineering, fabricating, and installing signs to prevent buckling, opening of joints, over stressing of components and connections, and other detrimental effects. Base engineering calculation on actual surface temperatures of materials due to both solar heat gain and nighttime sky heat loss.
  - a. Temperature Change (Range): 0 - 180 deg F ambient, material surfaces.
5. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

### **1.4 SUBMITTALS**

- A. All submittals shall be provided to both the Architect and the MBTA Design and Construction Department for review; disposition and documentation management will be provided by the MBTA Design and Construction Department.
- B. Product Data: Manufacturer's product data, any limitations and recommendations for each material used, installation instructions, and manufacturer's certification (stating that materials comply with requirements) for the Architect and MBTA Design and Construction Department's review and approval.
- C. Shop Drawings: Submit shop drawings for fabrication and installation of each sign assembly, including, but not limited to: sign frames and associated sign panels drawings, plans and elevations; sign content elevation (from SIGNmaker™ 1/2"=1'-0" elevation export file); and large-scale details of each sign frame and sign panel showing all required mounting holes, slots, clips, flanges, and other integral fastener components and accessory items. Provide four copies of shop drawings for action by the Architect and MBTA Design and Construction Department. After action provide two copies of shop drawings on which action has been taken to the Architect and MBTA Design and Construction Department for the Architect and MBTA Design and Construction Department's records.
- D. Sign Schedules: Submit complete Sign Schedule for each sign. Use same designations as indicated on the construction drawings. For signs scheduled to fit into existing frames, field verify dimensions of existing frames, noting clear openings and sign panel sizes in the sign schedule. Notify the MBTA Design and Construction Department in writing of any sizes variances from the construction documents so that adjustments can be made to the final sign fabrication files.



- E. Samples for Approval: Sample Submittals are in addition to quantities shown in sign schedule. They are record project samples to be kept on file at the MBTA Design and Construction Department's office.
1. Paper Proofs: To be provided within 30 business days from the MBTA Design and Construction Department's submittal of digital artwork. Fabricator proofs for:
    - a. For each Sign Assembly/Content Type listed on the signage schedules, provide half-size samples of the entire sign, and up to ten full-size proofs as determined by the MBTA Design and Construction Department.
    - b. For Art and mural panels (if indicated), provide full size paper proofs; Graphic artwork provided by the MBTA Design and Construction Department.
    - c. Submit 3" x 4" samples of each color and color shape on all substrates specified for each. For Art panels provide 12" x 12" sample on specified substrate.
  2. Approval of all proofs is required from the Architect and MBTA Design and Construction Department prior to final signage production.
  3. Samples and proofs will be resubmitted until they meet quality standards outlined in the next section.
  4. Provide samples and proofs to the Architect and MBTA Design and Construction Department at no extra charge.
  5. Mock-ups: Provide up to ten full-size mock-ups in place of each type of sign for locations as determined by the MBTA Design and Construction Department, to verify selections made under sample submittals and to demonstrate aesthetic effects and quality of materials and execution. Build mock-ups to comply with the specified requirements, using materials indicated for final unit of Work.
    - a. If the Architect and MBTA Design and Construction Department determines mockups do not comply with requirements, provide new corrected sign(s) until mockups are approved.
    - b. Approved mock-ups may become part of the completed Work if undisturbed at time of Substantial Completion.

## **1.5 QUALITY ASSURANCE**

- A. MBTA Reference Standards: Comply with the MBTA Signage Guidelines V 07.2011.
- B. Reference Standards: The work shall conform to the codes and standards of the following regulatory Agencies and Authorities as further cited herein:
1. ADAAG: Americans with Disabilities Act Accessibility Guidelines
  2. ANSI: American National Standards Institute.
  3. ASTM: American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103 as published in "Compilation of ASTM Standards in Building Codes".
  4. MAAB: Massachusetts Architectural Access Board.
  5. PEI: Porcelain Enamel Institute, Inc., 1900 L Street N.W., Washington, DC, 20036 – "Specifications for Architectural Porcelain Enamel," PEI-1001 (S-100); and "Standard Tests for Special Properties and Classifications."
- C. Source: For each type of material required for the work of this section, provide Single-Source Responsibility. For each separate type of sign required, obtain signs from a single manufacturer.

- D. Accessibility: The ADAAG and the MAAB regulations are pertinent to the design and installation of items covered under the work of this Section. When guidelines conflict, the guideline giving greater access shall be applicable.
- E. Qualifications: The approved manufacturer shall have a minimum of 5 years of successful experience with similar work, and shall have a reputation for doing satisfactory work on time.
- F. Welding Standards: Comply with applicable provisions of the American Welding Society AWS D1.1 "Structural Welding Code".
  - 1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.
- G. Coating Applicator Qualifications: must be experienced in successfully applying specified coatings of the type indicated to specified materials, and equipped with the following:
  - 1. Application equipment required to apply a uniform coating as recommended by the coatings manufacturer.
- H. Engineering: The Contractor is responsible for the proper engineering of all items. The internal structure, dimensions and specifications for all items shall be indicated in the Contractor's shop drawings. Sign Contractor to engineer signs to proper level to withstand abuses of their environment.
- I. Coordination: The work in this Section shall be completely coordinated with the work of other Sections. Verify dimensions and work of other trades that adjoin materials of this Section before the installation of items herein specified. Cooperate with such trades to assure the steady progress of all work under this Contract.
- J. Project Meetings: The signage contractor and related subcontractors shall be required to attend project meetings at the Project site when required by the Architect and MBTA Design and Construction Department.
- K. Certification: Submit manufacturer's certification that materials furnished comply with requirements specified.
- L. Maintenance Instructions: Submit manufacturer's printed instructions for maintenance of each sign installed to the MBTA, including precautions for use of cleaning materials and solvents for paint removal, which could damage surfaces.
- M. Warranty:
  - 1. Submit a written Manufacturer's warranty for MBTA acceptance, signed by the manufacturer, agreeing to repair or replace panels that fail during the specified warranty period. Failures include, but are not limited to, the following:
    - a. Coating degradation.
    - b. Chipping, chalking, fogging or discoloration.
    - c. Fading.
    - d. Structural failure.
    - e. Delamination of applied graphics.
    - f. Delaminating or degradation of applied anti-graffiti coatings.
  - 2. Warranty Period:
    - a. Porcelain Steel Enamel – 10 years
    - b. Aluminum – 7 years

3. The Manufacturer's warranty is in addition to, and not a limitation of, other rights the MBTA may have under the Contract Documents.

## **1.6 DELIVERY, STORAGE AND HANDLING**

- A. Deliver and store work under this Section in a manner to prevent the cracking or stress of components, and to prevent mechanical damage or damage from the elements.
  1. Porcelain Enamel Signs: Store units at building site, under cover. Place units on minimum 4 in. high wood blocking. Do not use non-ventilating plastic or canvas shelters that could create humidity chambers. If package becomes wet, remove carton and crating immediately. Provide 1/4 in. spaces between stacked units to promote air circulation.
- B. Deliver work under this Section to Site in ample time to avoid delay in job progress and at such times as to permit proper coordination of the various parts.
- C. Installation of this work shall be scheduled to occur near time of Substantial Completion.
- D. Handle signs carefully to prevent breakage, surface abrasion, denting, soiling, and other defects. Comply with the manufacturer's written handling instructions for unloading components subject to damage. Inspect sign components for damage on delivery.
  1. Do not install damaged sign components.
  2. Repair minor damage to signs, provided the finished repair is equal in all respects to the original work and is approved by MBTA; otherwise, remove and replace damaged sign components.

## **1.7 PROJECT CONDITIONS**

- A. Inspection of Site: The Contractor shall visit the site of the proposed work and become fully acquainted with existing conditions, and to become fully informed as to the facilities involved and the difficulties and restrictions attending the performance of the Contract, prior to submitting a price quotation.
- B. Substrates: Proceed with work of this Section only when substrate construction and penetration work have been completed.

# **PART 2 - PRODUCTS**

## **2.1 SUPPLIED GRAPHICS**

- A. SIGNmaker™ Digital Graphics files: The MBTA Design and Construction Department will prepare and supply all digital sign content to the contractor using the SIGNmaker™ software application. This application will provide 1/2" scale elevation drawings of all signs for contractor use in preparing shop drawings; it will also provide full size sign layouts for direct fabrication from digitally provided files. The contractor is responsible for verifying that each sign frame and sign panel is coordinated with the dimensions and content of supplied digital sign files, and for fabricating and installing all signs based on the MBTA Design and Construction Department's supplied graphic layouts of signs, maps and associated panels.

- B. Formats: Digital files produced from SIGNmaker™ are exported as .EPS format for use in final fabrication of signs, and as .PNG format to facilitate ½” scale elevation drawings for insert into AutoCad shop drawings.
- C. Output: SIGNmaker™ produces vector graphics that do not contain editable fonts. Any typographic editing must be done by the MBTA Design and Construction Department using SIGNmaker™ and re-exported to the contractor.
- D. Colors: Match all spot colors using the Pantone Matching System (PMS) or as per file designation in the digital files and in compliance with the standard colors as identified in the MBTA Signage Guidelines. Color samples, PMS color swatches, and proofs are to be provided to the MBTA Design and Construction Department at no extra charge. Standard PMS Colors by Line:

<u>Line</u>	<u>PMS Color</u>
Blue Line	293 C
Green Line	348 C
Orange Line	152 C
Red Line	485 C
Silver Line	430 C
Commuter Rail (purple)	249 C
Amtrak (brand color)	302 C
Bus (Yellow)	123 C

- E. Mural Panels: Final digital artwork for the mural panels will be supplied by the MBTA Design and Construction Department to the contractor. The contractor shall be responsible for the fabrication of the artwork, adhering to industry standards of quality and procedures. When one image spans several panels, either a larger sized porcelain panel will be required, or margins shall be minimized to reduce white seams.
  - 1. Resolution of final sign output by fabricator must be in vector format (not raster format) with a minimum resolution of 150- 300 LPI. Final output shall match EPS digital files for accurate layout, smoothness of contours and letter forms, and evenness of colors.
  - 2. Fabricator must provide written documentation of their capabilities/specs to the MBTA to show resolution output capability of equipment - line screens (LPI).

## 2.2 MATERIALS

- A. Porcelain Enamel on Steel Signs:
  - 1. Acceptable Porcelain Enamel Sign Manufacturers: Provide products of one of the following manufacturers or approved equal if they meet the requirements of these specifications:
    - a. Winsor Fireform Porcelain, Inc., Tumwater, WA
    - b. Cherokee Porcelain Enamel Corp., Knoxville, TN
    - c. KVO Industries, Inc., Santa Rosa, CA
  - 2. Metal Preparation/Cleaning:
    - a. All panels shall be degreased by immersion in an approved degreasing fluid. The panels shall then be rinsed in a heated water bath.
    - b. After the first rinse, panels shall be immersed in a caustic solution sufficient to provide an "etched" surface capable of good porcelain adherence. The panels shall then be rinsed.

- c. After the third rinse, the chemical action shall be neutralized in a soda ash solution then dried rapidly.
  - 3. Porcelain Enameling:
    - a. A porcelain enamel ground coat shall be applied to all areas of each unit, including backside and flanges, by spraying methods recognized by the Porcelain Enamel Institute. At least one additional separately fired cover-coating shall be applied to the face side and flanges of each unit. For corrosion protection and flatness, one additional coating shall be applied to the backside of each panel.
    - b. Apply digitally supplied sign content graphics by silkscreen process; each color shall be fired separately and shall be uniform and even.
  - 4. Finish and Background Color Control
    - a. Color to match approved samples based on MBTA standard colors.
    - b. Continuity of coating: Visual inspection of each unit shall reveal no visible breaks, gas bubbles, scumming, hairlines, stress lines or surface defects in the cover coat.
    - c. Check color at each application of enamel with a Hunter Lab D-25 P.C. color difference meter. Produce colors within the limits established during processing of submittals.
    - d. The color and finish shall match a color sample previously submitted to and approved by the MBTA Design Department.
  - 5. Ground and Covercoat Thickness
    - a. Ground and covercoat thickness shall be applied in accordance with PEI recommendations to a thickness range between 0.004 to 0.020", as required by the manufacturer to suit the intended use.
  - 6. Firing
    - a. Panels shall be fired in a continuous furnace (not a batch-type furnace) at a temperature between 1450 - 1600 degrees Fahrenheit to fuse the porcelain enamel to the metal, expel any volatile matter, and ensure color uniformity.
    - b. After firing, every panel is submitted to a visual inspection for color consistency against the control panel as approved by the MBTA.
  - 7. Glasses
    - a. Glasses used in the screening process shall be acid resistant and opaque. The glasses shall be corrosion proof, UV proof, wind proof, and vandal resistant. All screen glass must be milled to a 400 mesh particle size or smaller.
  - 8. Mural Panels
    - a. When one image spans several panels, either a larger sized porcelain panel will be required, or margins shall be minimized to reduce white seams.
- B. Aluminum Signs
- 1. Acceptable Aluminum Sign Manufacturers: Provide products from manufacturers if they meet the requirements of the specifications following.
  - 2. Aluminum Grade: Alloy 6063-T5 aluminum sheet. Thicknesses as indicated on the sign schedule
    - a. Surfaces constructed to remain flat under installed conditions within a tolerance of plus or minus 1/16 inch (1.5 mm) measured diagonally from corner to corner. Increase metal thickness or reinforce with concealed stiffeners or backing materials as required to produce surfaces without distortion, buckles, warp, or other surface deformations.
    - b. Unframed Single Sheet Panels: Provide unframed single sheet sign panels with edges mechanically and smoothly finished. The thickness of the aluminum sheeting shall be as shown on the plans or in these specifications.

- c. Aluminum panels shall be free of buckles, warps, dents, cockles, burrs, and any other defects resulting from fabrication processes.
  - d. All possible fabrication including shearing, cutting and punching of holes shall be completed prior to pretreatment of the sheeting.
- 3. Coordinate dimensions and attachment methods to produce message panels with closely fitting joints. Align edges and surfaces with one another in the relationship indicated.
- 4. Continuously weld joints and seams unless other methods are indicated; grind, fill, and dress welds to produce smooth, flush, exposed surfaces with welds invisible after final finishing.
- 5. Provide concealed sealing of joints to exclude water and provide corrosion protection, exclude sealing of joints where drainage of moisture will be inhibited - do not seal weep holes. Seal joints with specified sealers. For exposed sealers, provide color to match finish. Provide joint sealers tested for adhesion and compatibility with specified materials and finishes.
- 6. Mounting Method: Provide members with pins of length shown; for installation, weld to base plates or mechanically fasten where shown unless otherwise indicated. Provide turned pins and other anchorage provisions to resist vandalism and theft.
- 7. Silk screening imaging: screen printed graphics shall be produced directly from full-sized SIGNmaker™ digital files, provided to the contractor as final approved graphics. Graphic files shall utilize digitally-prepared screens and shall be printed in accordance with accepted industry standards. No hand-cut screens will be accepted. All screen printing shall be executed in such a manner that all edges and corners of letterforms are true and clean. Letterforms, color areas, or lines with rounded positive or negative corners, built-up edges, bleeding, spattering, etc. will not be accepted. All inks shall be applied evenly without pinholes, scratches, orange peeling, etc. All silk screening processes shall be approved by the MBTA prior to fabrication.
- 8. Finishes:
  - a. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations relative to applying and designating finishes.
  - a. The front and back surfaces of all aluminum panels shall be cleaned, deoxidized, and coated with a light, tightly adherent chromate conversion coating free of any powdery residue.
  - b. Shop finish individual components prior to mechanical assembly.
  - c. Color to match approved samples based on MBTA standard colors.
  - d. Shop Painting of Panel Faces:
    - 1) Abrasive brush blasting preparation (SSPC-SP7) to a 100-mesh sandpaper texture.
    - 2) Finish Coats: Provide intermediate and finish coats of "Imron Elite" polyurethane enamel or approved equal to achieve the colors and matte finish selected by the MBTA.
- 9. Anti-graffiti coating
  - a. For signs scheduled to receive anti-graffiti coating, provide a high-durability, "permanent type" quality, matte finish, non-yellowing, and suitable for painted aluminum surfaces, as manufactured by one of the following companies, or approved equal:
    - 1) Monopole, Monochem Permashield Premium
    - 2) Dumond CPU 647 Graffiti Barrier Coat
    - 3) Adsil Microguard AD00
  - b. Apply anti-graffiti coatings in strict accordance with manufacturers instructions
  - c. Warranty: 10 years

C. Map Frame Assembly

1. Supply map frame assemblies and hardware as indicated on the drawings.
2. Stainless Steel Frame:
  - a. 22 gauge 316 stainless steel.
  - b. Brushed finish.
  - c. Stainless steel fasteners with nylon bushing.
3. Lexan Sheet:
  - a. 1/4" LEXAN MR10 abrasion resistant polycarbonate sheet.
4. Aluminum Backer:
  - a. Alloy 6063-T5 0.080" formed aluminum panel.
  - b. Alloy 6063-T6 aluminum tubes and stiffeners as indicated on drawings.
5. All hardware shall be as indicated on drawings.

D. Hardware and Frames

1. Supply sign frames and hardware as indicated on the drawings.
2. Structural steel materials, details and workmanship shall conform to the specifications of the latest edition of the A.I.S.C. Specifications for the Design, Fabrication, and Erection of Structural Steel Buildings. ASTM standards:
  - a. Extruded Bars and Shapes: ASTM B 221 (ASTM B 221M), 6063-T6.
  - b. Plate and Sheet: ASTM B 209 (ASTM B 209M), 6061-T6.
  - c. Die and Hand Forging: ASTM B 247 (ASTM B 247M), 6061-T6.
  - d. Castings: ASTM B 26/B 26M, A356-T6.
3. Anchors and Inserts: Use non-ferrous metal or hot-dipped galvanized anchors and inserts for exterior installations and elsewhere as required for corrosion resistance. High strength bolts other than anchor bolts, nuts and washers shall conform to ASTM-A325. Use toothed steel or lead expansion bolt devices for drilled-in-place anchors. Furnish inserts, as required, to be set into concrete or masonry work.
4. Tamper resistant fasteners to be stainless steel, 3/8" dia. button head Phillips socket pinhead.
5. Threaded studs shall be low carbon mild steel with a minimum yield strength of 50,000 PSI.
6. All hardware shall be as indicated on drawings: 316 stainless steel, or galvanized per ASTM-A153 requirements.
7. Where mechanical fasteners and hardware are required, they shall be of adequate thickness, length and construction to properly secure the sign unit. Any visible portion of any mounting device shall be finished to match adjacent sign surface, unless otherwise specified.
8. Non-metallic Washers: Provide rigid neoprene separators between fasteners and non-compatible materials being joined.
9. Welding Electrodes and Filler Metal: Type and alloy of filler metal and electrodes as recommended by producer of metal to be welded, complying with applicable AS specifications, and as required for color match, strength, and compatibility in the fabricated items.
10. Galvanizing Repair Paint: High zinc dust content paint for re-galvanizing welds in galvanized steel, with dry film containing not less than 94 percent zinc dust by weight, complying with DOD- P-21035 or SSPC-Paint 20.
11. Backing Materials: 1/2" cement board backing, for locations requiring non-combustible assemblies - Hardibacker 500 Board or equal. Where combustible materials are allowed, backing may be 1/2" APA Graded, Exterior Grade A-C Plywood and Marine Grade Plywood, as indicated on the drawings.

E. Adhesives:

1. Where adhesive mounting techniques are specified, the Contractor shall use adhesives specifically designed for compatibility with the base materials and the desired adhesive strength. All adhesives shall be tested on site. All adhesives shall be indicated in the shop drawings.
2. Surfaces on which signage is to be installed using adhesive shall be free of grease, oil, or any other residue.
3. Foam tape shall be 1/32" thick, high-density open cell double coated polyurethane foam tape for applications indicated as manufactured by the 3M Co. or approved equal.
4. Very high bond (VHB) tape shall be double coated acrylic foam tape.

F. Sealant:

1. For joints indicated in the drawings, provide silicone sealant that meets or exceeds the industry specifications TT-S-230C Class A, ASTM C 920, Class 50, Type S, Grade NS as manufactured by one of the following companies, or approved equal:
  - a. Tremco, Spectrem 1
  - b. Pecora, 864NST
2. Install in strict accordance with manufacturer's instructions.
3. Surface Preparation: prepare joints in accordance with ASTM C 1193 and manufacturer's instructions. For good adhesion, the joint interface must be sound, clean and dry. Clean joint surfaces to remove dirt, dust, oils, wax, paints, and other contamination capable of affecting primer and sealant bond.
4. Joint-Sealant Backing:
  - a. General: provide sealant backings of material and type that are non-staining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.
  - b. Elastomeric Tubing Sealant Backings: neoprene, butyl, EPDM, or silicone tubing complying with ASTM D 1056, nonabsorbent to water and gas, and capable of remaining resilient at temperatures down to minus 26 deg F. Provide products with low compression set and of size and shape to provide a secondary seal, to control sealant depth, and to otherwise contribute to optimum sealant performance.
  - c. Bond-Breaker Tape: polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surface at back of joint where such adhesion would result in sealant failure. Provide self-adhesive tape where applicable.
5. Color: match to frame color as closely as possible – use dark sealant with dark-colored frames and light sealant with light-colored (or galvanized) frames.

## 2.3 Fabrication

A. Porcelain Enamel Signs:

1. ASTM A424. Porcelain sign panels shall be #16 gauge prime vitreous enameling steel finished with non-fading class A or AA acid resisting Architectural porcelain enamel in color specified, fused to the metal at temperatures between 1450 F to 1600 F. Porcelain enamel sign panels shall be of the best commercial quality and their forms shall be flat, straight, and true. Finish shall be non-reflective matte. Base metal shall receive a ground coat on all surfaces and successive face coats as required on the front and on all flanges. Silkscreened color shall be applied to face surface only. Exercise extreme care in all handling and stacking of porcelain work to avoid chipping. Graphics shall be of high resolution as per specifications.



2. Fabricate from pan-formed porcelain enameled steel plate with flat-flanged edges. All forming shall be mechanical and done in advance of welding.
  3. Precisely form work to sizes, shapes, and profiles indicated on approved shop drawings. Fabricate work with uniform joints that are not visible. Work to be truly straight, plumb, level and square with smooth flat surfaces and sharp corners
  4. All welds shall be clean, sound and solid, free from defects and gas bubbles, and ground and sanded smooth to 3/16" to match the 3/16" radii of the mechanical break. They shall be done using a hand oxyacetylene fusion technique with no additions of foreign metals.
  5. All necessary holes and cutouts shall be drilled or punched and welded in advance of enameling, with edges sufficiently ground to hold a porcelain coating.
  6. Fabricate laminated sandwich construction, consisting of front sheet of porcelain enameled steel plate, on a 1/2 in. thick Marine Grade plywood core, with a layer of galvanized steel backing.
- B. Aluminum Signs
1. Coordinate dimensions and attachment methods to produce message panels with closely fitting joints. Align edges and surfaces with one another in the relationship indicated.
  2. Continuously weld joints and seams, unless other methods are indicated; grind, fill, and dress welds to produce smooth, flush, exposed surfaces with welds invisible after final finishing.
  3. Provide concealed sealing of joints to exclude water and provide corrosion protection, exclude sealing of joints where drainage of moisture will be inhibited, and do not seal weep holes. Seal joints with specified sealers, and for exposed sealers, provide color to match finish. Provide joint sealers tested for adhesion and compatibility with specified materials and finishes.
  4. Mounting Method: Provide members with pins of length shown for installation weld to base plates or mechanically fasten where shown unless otherwise indicated. Provide turned pins and other anchorage provisions to resist vandalism and theft.

## **PART 3 - EXECUTION**

### **3.1 INSPECTION**

- A. The Installer shall examine substrates, supports, and conditions under which this work is to be performed, and notify the Contractor and the Architect in writing of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning work means Installer accepts substrates and conditions.
- B. Notification Point: The Architect and MBTA Design and Construction Department will be given 72 hour notice to perform field inspection at the start of installation of signage. If work does not meet project requirements, contractor must remove and replace deficient work.

### **3.2 INSTALLATION/APPLICATION/ERECTION**

- A. All locations where signs are to be installed new or retrofitted to existing frames must be field measured by contractor. This must be documented and sent to the MBTA Design and Construction Department prior to final digital artwork submittal and fabrication of signage.
- B. Strictly comply with approved shop drawings and manufacturer's instructions and recommendations, except where more restrictive requirements are specified in this Section.

- C. Install work plumb, level, and in true plane and alignment. Provide signs and graphics where shown or scheduled using mounting methods indicated.
- D. Protect adjacent or adjoining surfaces and work from damage during installation in this Section.
- E. Work shall be designed and anchored so that work will not be distorted nor the fasteners overstressed from expansion and contraction of metal or other materials as applicable.

### **3.3 TOLERANCES**

- A. The following installed tolerances are allowable variations from locations and dimensions indicated by the Contract Document and shall not be added to allowable tolerances indicated for other work:
  - 1. Allowable Variation from True Plumb, Level and Line: Plus or minus 1/32 inch from true position for signage smaller than 24 by 24 inches in size; plus or minus 1/16 inch from true position for signage 24 by 24 inches in size and larger.
  - 2. Allowable Variation from True Plane of Adjacent Surfaces: Plus or minus 1/16 inch.

### **3.4 CLEANING AND PROTECTION**

- A. Adjust work to present the best possible appearance. Touch-up damaged finishes and eliminate any evidence of repair. Clean exposed surfaces using materials and methods recommended by manufacturer of material or product being cleaned. Remove and replace work that cannot be successfully repaired or cleaned.
- B. Provide temporary protection to ensure work is delivered without damage or deterioration at time of final acceptance. Remove protections and reclean as necessary immediately before final acceptance.
- C. Manufacturer shall provide Authority with information on cleaning and maintenance recommendations for all signs.
- D. Names, stamps and decals of manufacturers, installers or maintainers of signs shall not be visible in the finished work.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of all fixed signage for the BRT Stations.

### **END OF SECTION**

## **SECTION 10426**

### **TACTILE/BRAILLE SIGNAGE**

#### **PART 1 - GENERAL**

##### **1.1 DESCRIPTION OF WORK**

- A. Work Included: This Section specifies all ADA-required Tactile/Braille signage as indicated on the Drawings and specified herein.
- B. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
  - 1. Section 05500 – MISCELLANEOUS METALS
  - 2. Section 10100 – DISPLAY CASES
  - 3. Section 10400 – FIXED SIGNAGE
  - 4. Division 16 – ELECTRICAL - “Variable Message Signs”.
- C. Permits: Obtain permits as required by Local Authorities for installation of signs.

##### **1.2 SUBMITTALS**

- A. Product Data: Manufacturer's product data, any limitations and recommendations for each material used, installation instructions, and manufacturer's certification (stating that materials comply with requirements) for the Architect's and MBTA Design and Construction Department's review and approval.
- B. Approval Drawings: Provide dimensioned shop drawings of each individual sign, based on .eps files supplied by the MBTA Design and Construction Department, along with a complete sign schedule utilizing the same designations as indicated on the MBTA Design and Construction Department's drawings. The shop drawings must represent exactly what will be etched on each sign. No fabrication shall take place without approval of the shop drawings by the Architect and MBTA Design and Construction Department.
- C. Provide four copies of shop drawings for action by the Architect and MBTA Design and Construction Department.
- D. Samples for Approval:
  - 1. Provide one full-size, complete sample of a representative sign, etched, painted and finished, for approval by the Architect and MBTA Design and Construction Department.
  - 2. ADA compliance: Contractor shall complete the attached “ADA Tactile/Braille Metrics Check list” to assure that all metrics of sample sign are in compliance with ADA defined metrics.
  - 3. Approval of sample sign is required from the Architect and MBTA Design and Construction Department prior to final signage production.
  - 4. Sample will be resubmitted, if necessary, until it meets quality standards outlined in the next section.
  - 5. Once approved, the sample sign will be forwarded to the project site for installation (completed sample sign to be provided to the Architect and MBTA Design and Construction Department at no extra charge).

### 1.3 QUALITY ASSURANCE

- A. Reference Standards: The work shall conform to the codes and standards of the following regulatory Agencies and Authorities as further cited herein:
  - 1. ADA: Americans with Disabilities Act 2010 Standards
  - 2. ANSI: American National Standards Institute.
  - 3. ASTM: American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103 as published in "Compilation of ASTM Standards in Building Codes".
  - 4. MAAB: Massachusetts Architectural Access Board.
- B. Performance Requirements
  - 1. Painted Sign Finish shall comply with the following performance requirements:
    - a. Weatherability: When tested in accordance with ASTM G 53, after 500 hours in Weatherometer (equivalent to approximately 3 years exterior exposure):
    - b. Gloss retention not less than 88.0 determined in accordance with ASTM D 523 at a 60 degree angle.
    - c. Color shall not change more than 1.68 units determined in accordance with STM D 2244 and measured with a Hunter Colorimeter, Model D25.
  - 2. Durability: Sign finish shall not effect after repeated use of cleaners such as Graffiti Remover #1120 manufactured by Organics Corp., Lodi, NJ.
- C. Source: For each type of material required for the work of this section, provide Single-Source Responsibility.
- D. Accessibility: The ADA 2010 Standards and the MAAB regulations are pertinent to the design and installation of items covered under the work of this Section. When guidelines conflict, the guideline giving greater access shall be applicable.
- E. Qualifications: The approved manufacturer shall have a minimum of 5 years of successful experience with similar work, and shall have a reputation for doing satisfactory work on time.
- F. Coordination: The work in this Section shall be completely coordinated with the work of other Sections. Verify dimensions and work of other trades that adjoin materials of this Section before the installation of items herein specified. Cooperate with such trades to assure the steady progress of all work under this Contract.
- G. Certification: Submit manufacturer's certification that materials furnished comply with requirements specified.
- H. Maintenance Instructions: Submit manufacturer's instructions for maintenance of tactile/braille sign to the MBTA, including precautions for use of cleaning materials and solvents.
- I. Warranty:
  - 1. Submit a written Manufacturer's warranty for MBTA acceptance, signed by the manufacturer, agreeing to repair or replace panels that fail during the specified warranty period. Failures include, but are not limited to, the following:
    - a. Coating degradation.
    - b. Chipping, chalking, fogging or discoloration.
    - c. Fading.

2. Warranty Period: 1 year from product ship date.

#### **1.4 DELIVERY, STORAGE AND HANDLING**

- A. Deliver and store work under this Section in a manner to prevent the cracking or stress of components, and to prevent mechanical damage or damage from the elements.
- B. Deliver work under this Section to Site in ample time to avoid delay in job progress and at such times as to permit proper coordination of the various parts.
- C. Installation of this work shall be scheduled to occur near time of Substantial Completion.
- D. Inspect sign components for damage on delivery.
  1. Do not install damaged signs. Replace any damaged signs with new signs.

#### **1.5 PROJECT CONDITIONS**

- A. Inspection of Site: The Contractor shall visit the site of the proposed work and become fully acquainted with existing conditions, and to become fully informed as to the facilities involved and the difficulties and restrictions attending the performance of the Contract, prior to submitting a price quotation.
- B. Substrates: Proceed with work of this Section only when substrate construction and penetration work have been completed.

### **PART 2 - PRODUCTS**

#### **2.1 SUPPLIED GRAPHICS**

- A. The MBTA Design and Construction Department will prepare and supply all digital sign graphics (physical size, layout and content) in .eps format for etching. All graphic files are vector graphics, no font replacement is necessary.

#### **2.2 MATERIALS**

- A. Zinc Signs
  1. 0.125" one-piece zinc plate, utilizing chemical etch process to produce raised characters in compliance with ADA and supplied graphics. Chamfer or ease all sides and corners to remove sharp edges.
  2. Acceptable Manufacturers: the following is a partial list of zinc signage manufacturers:
    - a. Vivid Manufacturing
    - b. Dixie Graphics
    - c. Kroy Sign Systems
    - d. Etchcraft Incorporated
    - e. Advance Corporation
    - f. ADA Signs
    - g. ASI
    - h. ASE Manufacturing

**B. Attachments**

**1. Mechanical:**

- a. Threaded inserts appropriate to substrate material – 4 per sign
- b. Tamper resistant, 1/4" diameter stainless steel Flat Head Phillips Pin-Head screws. Screws shall seat into countersunk holes such that when fully tightened the screw head is flush with sign background surface. Paint screws to match background paint color of sign
- c. Non-metallic Washers: Provide rigid neoprene separators between fasteners and non-compatible materials being joined.

**2. Adhesive:**

- a. Where adhesive mounting techniques are specified, very high bond (VHB) tape specifically designed for compatibility with the base materials and the desired adhesive strength shall be used. All adhesives shall be tested on site. All adhesives shall be indicated in the shop drawings.
- b. Very high bond (VHB) tape shall be double coated acrylic foam tape as manufactured by the 3M Co., or approved equal.
- c. Surfaces on which signage is to be installed using adhesive shall be free of grease, oil, or any other residue.

**2.3 Fabrication**

**A. Zinc Signs:**

- 1. Etching: Signs reverse-etched to create all tactile text, lines, arrows, and braille glyphs raised 1/32" high. Braille glyphs shall be standard rounded grade 2 Braille as rendered in the EPS files. Cross section angle of raised characters shall not exceed 45 degrees. Text and Braille shall be finished to provide smooth, non-pointed edges. Background surface shall be smooth texture.
- 2. Finishes:
  - a. Background - Mathews baked-on acrylic polyurethane enamel paint with eggshell/matte finish. Custom color shall be: PMS 446 (very dark grey).
  - b. Foreground - (Tactile lettering only) brushed natural zinc with U.V. resistant clear urethane topcoat.
  - c. Predrilled holes: Provide four 1/4" counter sunk mounting holes, centered 3/8" from edges, only in corners of signs scheduled to be screw attached. All other signs to be provided without mounting holes.

**PART 3 - EXECUTION**

**3.1 INSPECTION**

- A. Prior to installation, the Installer shall examine substrates, supports, and conditions under which this work is to be performed, and notify the Contractor and the Architect in writing of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning work means Installer accepts substrates and conditions.

- B. Notification Point: Architect and MBTA Design and Construction Department will be given 72 hour notice to perform field inspection prior to the start of signage installation. The MBTA Design and Construction Department shall conduct a detailed inspection of all tactile/braille signs to be installed prior to installation to assure compliance with the supplied drawings. A formal signoff by the MBTA Design and Construction Department must be executed prior to commencement of any installation. If work does not meet project requirements, contractor must replace deficient work.

### **3.2 INSTALLATION/APPLICATION/ERECTION**

- A. All locations where signs are to be installed new or retrofitted to existing frames must be field measured by contractor. This must be documented and sent to the Architect and MBTA Design and Construction Department prior to final digital artwork submittal and fabrication of signage.
- B. Strictly comply with approved shop drawings and manufacturer's instructions and recommendations, except where more restrictive requirements are specified in this Section.
- C. Install work plumb, level, and in true plane and alignment. Provide signs and graphics where shown or scheduled using mounting methods indicated.
- D. Protect adjacent or adjoining surfaces and work from damage during installation in this Section.
- E. Work shall be designed and anchored so that work will not be distorted nor the fasteners overstressed from expansion and contraction of metal or other materials as applicable.
- F. The Tactile/Braille signs are small in size and shall be installed plumb and square. In the event that an adjacent material, such as a doorframe, is slightly out of plumb, the contractor shall install the Tactile/Braille sign parallel so as to minimize the visual conflict.

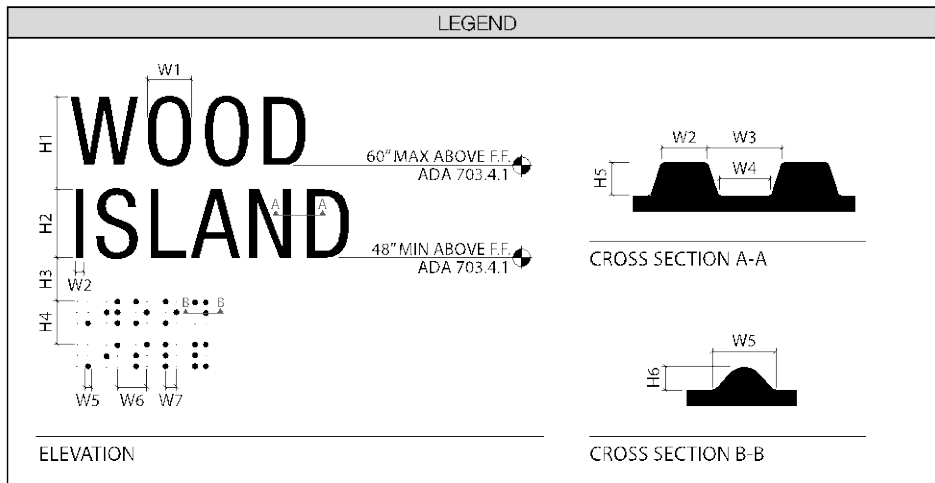
### **3.3 CLEANING AND PROTECTION**

- A. Adjust work to present the best possible appearance. Touch-up damaged finishes and eliminate any evidence of repair. Clean exposed surfaces using materials and methods recommended by manufacturer of material or product being cleaned. Remove and replace work that cannot be successfully repaired or cleaned.
- B. Provide temporary protection to ensure work is delivered without damage or deterioration at time of final acceptance. Remove protections and reclean as necessary immediately before final acceptance.
- C. Manufacturer shall provide Authority with information on cleaning and maintenance recommendations for all signs.
- D. Names, stamps and decals of manufacturers, installers or maintainers of signs shall not be visible in the finished work.

### **3.4 ADA Compliance Checklist**

- A. Tactile/Braille signs must comply with the dimensional requirements of ADA 703.3 (2010). The following legend graphically illustrates each ADA 703.3 metric.

- B. Once a mockup has been fabricated, and prior to submission for approval, the fabricator must complete the following check list to assure that the sample product is in complete compliance with ADA metrics. Completed checklist must be submitted with sample sign for approval. Samples submitted without a completed checklist will be rejected.
- C. Tactile metrics legend





## D. ADA 703.2 and 703.3 Compliance Checklist

ADA 703.2 – Raised Characters						
Legend Symbol	ADA Reference	Description	ADA Values	ADA Values for 5/8" Text	Check by Contractor	Check by Designer
H5	703.2.1 Depth	Depth of character above background	$\geq 1/32"$ (0.8 mm)	-		
-	703.2.2 Case	All Uppercase	Y/N	-		
-	703.2.3 Style	Sans serif, not italic, oblique, script, highly decorative, or of unusual forms	Y/N	-		
W1	703.2.4 Character Proportions	Width of uppercase "O" relative to height of uppercase "I" (H2)	$0.55 \leq W1/H2 \leq 1.1$	Min: 0.344" Max: 0.743"		
H2	703.2.5 Character Height	Height of uppercase "I"	$0.625" \leq H2 \leq 2"$ $16 \text{ mm} \leq H2 \leq 51 \text{ mm}$	0.625"		
W2	703.2.6 Stroke Thickness	Width of uppercase "I" relative to height of uppercase "I" (H2)	$W2/H2 \leq 0.15$	$\leq 0.094"$		
W3	703.2.7 Character Spacing	Rectangular cross section or top of beveled cross section	$0.125" \leq W3 \leq 4(W2)$ $3.2 \text{ mm} \leq W3 \leq 4(W2)$	Min: 0.125" Max: 0.376"		
W4	703.2.7 Character Spacing	Base of beveled cross section	$0.0625" \leq W4 \leq 4(W2)$ $1.6 \text{ mm} \leq W4 \leq 4(W2)$	Min: 0.063" Max: 0.376"		
H1	703.2.8 Line Spacing	Distance between baselines of raised characters relative to height of uppercase "I" (H2)	$1.35 \leq H1/H2 \leq 1.7$	Min: 0.844" Max: 1.063"		

ADA 703.3 – Braille						
Legend Symbol	ADA Reference	Description	ADA Values	-	Check by Contractor	Check by Designer
-	703.3.1 Dimensions & Capitalization	Domed or rounded shape	Y/N			
-	703.3.1 Dimensions & Capitalization	Uppercase letters only before first word of sentences, proper nouns and names, individual letters of the alphabet, initials, acronyms	Y/N			
W5	703.3.1 Braille Dimensions	Dot base diameter	Min: 0.059" (1.5 mm) Max: 0.063" (1.6 mm)			
W7	703.3.1 Braille Dimensions	Distance between two dots in the same cell	Min: 0.090" (2.3 mm) Max: 0.100" (2.5 mm)			
W6	703.3.1 Braille Dimensions	Distance between corresponding dots in adjacent cells	Min: 0.241" (6.1 mm) Max: 0.300" (7.6 mm)			
H6	703.3.1 Braille Dimensions	Dot Height	Min: 0.025" (0.6 mm) Max: 0.037" (0.9 mm)			
H4	703.3.1 Braille Dimensions	Distance between corresponding dots from one cell directly below	Min: 0.395" (10 mm) Max: 0.400" (10.2 mm)			
-	703.3.2 Position	Braille below corresponding text. If multi-lined, below entire text.	Y/N			
H3	703.3.2 Position	Distance from Braille to tactile characters, raised borders, and decorative elements.	$\geq 0.375"$ (9.5 mm)			

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of all tactile/braille signage for the BRT Stations.

**END OF SECTION**

## **SECTION 10428**

### **MBTA LOGO “LOLLIPOP” SIGN**

#### **PART 1 - GENERAL**

##### **1.1 DESCRIPTION OF WORK**

- A. Work Included: This Section specifies Massachusetts Bay Transportation Authority (MBTA) logo sign as indicated on the Drawings and specified herein. All modes of transport requiring a logo sign will use this specification to maintain consistency of appearance.
- B. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
  - 1. Section 05500 - MISCELLANEOUS METALS; Frames and supports not integral with signage.
  - 2. Division 16 - ELECTRICAL;
- C. Permits: Obtain permits required by Local Authorities for installation of signs.

##### **1.2 GRAPHICS**

- A. MBTA logo dimensions can be found in MBTA 2013 Logo Sign Guidelines and must be followed to ensure consistency. MBTA logo graphics can also be provided by MBTA Design and Construction Department.

##### **1.3 PERFORMANCE REQUIREMENTS**

- 1. Design Criteria: Design, fabricate, and install sign items to withstand normal exposure to weather, temperature variation, wind loads and building movement; provide units resistant to vandalism and theft.
- 2. Field Measurements: Check actual locations of construction - to which metal fabrications must fit - by accurate field measurements before fabrication; show recorded measurements on final shop drawings.
- 3. Thermal Movements: Allow for thermal movement resulting from the following maximum change (range) in ambient temperature in engineering, fabricating, and installing signs to prevent buckling, opening of joints, over stressing of components and connections, and other detrimental effects. Base engineering calculation on actual surface temperatures of materials due to both solar heat gain and nighttime sky heat loss.
  - a. Temperature Change (Range): 0 - 180 deg F ambient, material surfaces.
- 4. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

## **1.4 SUBMITTALS**

- A. All submittals shall be provided to both the Architect and MBTA Design and Construction Department for review; disposition and documentation management will be provided by the MBTA Design and Construction Department.
- B. Product Data: Manufacturer's product data, any limitations and recommendations for each material used, installation instructions, and manufacturer's certification (stating that materials comply with requirements) for the Architect and MBTA Design and Construction Department's review and approval.
- C. Shop Drawings: Provide shop drawings for fabrication and installation of logo sign including mounting. Provide plans, elevations, and details of anchorage, connections and accessory items. Provide installation templates for work installed by others. Provide four copies of shop drawings for action by the Architect and MBTA Design and Construction Department. After action provide two copies of shop drawings on which action has been taken to Architect and MBTA Design and Construction Department for Architect and MBTA Design and Construction Department's records.
- D. Sign Schedules: Submit complete Sign Schedule for logo sign. Use same designation as on the Drawings.
- E. Samples for Approval: Sample Submittals are in addition to quantities shown in sign schedule. They are record project samples to be kept on file at the Designer's office.
  - 1. Paper Proofs: Provide proofs for logo sign including half-size elevation sample of the entire logo sign.
  - 2. Submit 3" x 4" samples of polycarbonate lens material in white and black colors.
  - 3. Approval of all proofs is required from the Architect and the MBTA Design and Construction Department prior to final sign production.
  - 4. Color samples and paper proofs will be resubmitted until they meet quality standards outlined in the next section.
  - 5. Provide samples and proofs to the Architect and MBTA Design and Construction Department at no extra charge.

## **1.5 QUALITY ASSURANCE**

- A. MBTA Reference Standard: Comply with the MBTA Logo Sign Guidelines. A copy will be available on request from the MBTA Design and Construction Department.
- B. Reference Standards: The work shall conform to the codes and standards of the following agencies as further cited herein:
  - 1. ADAAG: Americans with Disabilities Act Accessibility Guidelines
  - 2. ANSI: American National Standards Institute
  - 3. ASTM: American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103 as published in "Compilation of ASTM Standards in Building Codes"
  - 4. MAAB: Massachusetts Architectural Access Board

5. Structural Code:
- a. Mass Building Code
  - b. AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals
- C. Accessibility: The ADAAG and the MAAB regulations are pertinent to the design and installation of items covered under the work of this Section. When guidelines conflict, the guideline giving greater access shall be applicable.
- D. Qualifications: The approved manufacturer shall have minimum of 5 years of successful experience with similar work, shall have a reputation for doing satisfactory work on time
- E. Welding Standards: Comply with applicable provisions of the American Welding Society AWS D1.1 "Structural Welding Code."
- 1. Certify that welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.
- F. Coating Applicator Qualifications: must be experienced in successfully applying specified coatings of the type indicated to specified materials, and equipped with the following:
- 1. Application equipment required to apply a uniform coating as recommended by the coatings manufacturer.
- G. Engineering: The Contractor is responsible for the proper engineering of all items. Supports shall be signed and sealed by a Professional Engineer registered in the Commonwealth of Massachusetts. The internal structure, dimensions and specifications for all items shall be indicated in the Contractor's shop drawings. Sign Contractor to engineer signs to proper level to withstand abuses of their environment.
- H. Coordination: The work in this Section shall be completely coordinated with the work of other Sections. Verify dimensions and work of other trades that adjoin materials of this Section before the installation of items herein specified. Cooperate with such trades to assure the steady progress of all work under this Contract.
- I. Hold Points: Completed logo sign shall be available for inspection for two weeks prior to installation, with notification given to the Architect and MBTA Design and Construction Department.
- 1. If Architect and MBTA Design and Construction Department determines sign does not comply with requirements, provide new logo sign until it is approved.
- J. Project Meetings: The signage contractor and related subcontractors shall be required to attend project meetings at the Project site when required by the Architect and MBTA Design and Construction Department.
- K. Certification: Submit manufacturer's certification that materials furnished comply with requirements specified.
- L. Maintenance Instructions: Submit manufacturer's printed instructions for maintenance of each sign installed to the MBTA, including precautions for use of cleaning materials and solvents for paint removal, which could damage surfaces.
- M. Warranty:

1. Submit a written Manufacturer's warranty for the MBTA acceptance, signed by the manufacturer, agreeing to repair or replace lenses that fail during specified warranty period. Failures include, but not limited to, the following:
  - a. Coating degradation
  - b. Chipping, chalking, fogging or discoloration.
  - c. Fading.
  - d. Structural failure.
  - e. Delamination of applied graphics.
  - f. Delaminating or degradation of applied anti-graffiti coatings.
2. The manufacturer's warranty is in addition to, and not a limitation of, other rights the MBTA may have under the Contract Documents.

## **1.6 DELIVERY, STORAGE AND HANDLING**

- A. Deliver and store work under this Section in a manner to prevent cracking or stress of components and to prevent mechanical damage or damage by the elements.
- B. Deliver work under this Section to Site in ample time to avoid delay in job progress and at such times as to permit proper coordination of the various parts.
- C. Installation of this work until near time of Substantial Completion.
- D. Handle signs carefully to prevent breakage, surface abrasion, denting, soiling, and other defects. Comply with the manufacturer's written handling instructions for unloading components subject to damage. Inspect sign components for damage on delivery.
  1. Do not install damaged sign components.
  2. Repair minor damage to signs, provided the finished repair is equal in all respects to the original work and is approved by MBTA; otherwise, remove and replace damaged sign components.

## **1.7 PROJECT CONDITIONS**

- E. Inspection of Site: The Contractor shall visit the site of the proposed work and become fully acquainted with existing conditions, and to become fully informed as to the facilities involved and the difficulties and restrictions attending the performance of the Contract, prior to submitting a price quotation.
- A. Substrates: Proceed with work of this Section only when substrate construction and penetration work have been completed.

# **PART 2 - PRODUCTS**

## **2.1 MATERIALS**

- A. Logo "Lollipop" Sign: Each sign will be shop fabricated by the contractor off-site and delivered and installed at the locations as shown on the Drawings.

- B. Lens: The lens shall be Solar Grade, vacuum-formed, UV resistant, high-impact polycarbonate convex sheets with 2 ½" bow. The polycarbonate shall be ¼" in thickness. The lens shall be white with a black "T" on the surface on both exterior sides. The black "T" logo shall be embossed such that it protrudes .375" out from the white background.
- C. Structural Steel:
1. The sign's post shall be a schedule 80 steel pipe, with an outer diameter of 3.5" and an inner diameter of 2.90". The pipe will be welded to steel gusset plate and steel base plate.
  2. The frame shall be a C4 x 5.4 steel rolled channel with ¼" weep holes, and opening wide enough for the pipe. The channel will be bent and welded to form a circle with the flange on the outside.
  3. The sign frame and support shall be shop painted steel.
    1. As shown on the contract drawings.
    2. Materials in accordance with 05500 Misc Metals.
- D. Sign Connections:
1. Logo sign attached and or supported as shown on the Drawings. Supports and connections as specified in section 05500 Misc Metals.
  2. Continuously weld joints and seams unless other methods are indicated; grind, fill, and dress welds to produce smooth, flush, exposed surfaces with welds invisible after final finishing.
  3. Logo sign pipe will be secured in Portland cement concrete or bituminous concrete sidewalks or other rigid surfaces and shall be in accordance with the Drawings. Any leveling of the sign baseplate to the concrete sub-base should be filled with a pourable cementitious, non-shrink grout.
  4. The polycarbonate lens will be mechanically fastened to the frame with two half-circle angle long leg in aluminum ring frame, for each sign face.
  5. Neoprene sponge between channel ring frame and lens shall conform to ASTM D1056, Type 2, Class C, Grade 2.
  6. The steel pipe will connect to the circular channel ring frame by sliding the pipe through hole cut at base of the channel ring. Two steel angle clips welded to the interior of the channel ring at the top and two at the bottom will be mechanically fastened to the pipe.
  7. All hardware shall be as indicated on drawings.
- E. Hardware:
1. Anchors and Inserts: Use non-ferrous metal or hot-dipped galvanized anchors and inserts for exterior installations and elsewhere as required for corrosion resistance. High strength bolts other than anchor bolts, nuts and washers shall conform to ASTM-A325.
  2. Tamper resistant fasteners to be stainless steel, 3/8" dia. button head Phillips socket pinhead.
  3. Threaded studs shall be low carbon mild steel with a minimum yield strength of 50,000 PSI.

4. All hardware shall be as indicated on drawings: 316 stainless steel, or galvanized per ASTM-A153 requirements.
  5. Where mechanical fasteners and hardware are required, they shall be of adequate thickness, length and construction to properly secure the sign.
  6. Welding Electrodes and Filler Metal: Type and alloy of filler metal and electrodes as recommended by producer of metal to be welded, complying with applicable AS specifications, and as required for color match, strength, and compatibility in the fabricated items.
  7. Galvanizing Repair Paint: High zinc dust content paint for re-galvanizing welds in galvanized steel, with dry film containing not less than 94 percent zinc dust by weight, complying with DOD- P-21035 or SSPC-Paint 20.
- F. Coatings: The logo sign frame, post, and anchors shall all receive the Exterior Ferrous Metal, Urethane system as specified in section 09900. Finish will be color semi-gloss black.
- G. Electrical:
1. Electrical wire shall be #12 and be a 2 wire system.
  2. Conduit shall be rigid galvanized steel.
  3. Twelve Light-Emitting Device (LED) shall be 5000K. Power supply shall be 277 Volt power damp rated. The LEDs will be tacked to two 3" wide steel sheet metal channels placed in the inside of the steel channel ring to either side of the pipe. These two channels will be bent with flanges out (opposite of channel ring frame bend), so that the wiring will fit between the steel sheet metal channel and the channel ring frame. See drawings for clarification.

## **2.2 FABRICATION**

- A. Precisely form work to sizes, shapes, and profiles indicated on approved shop drawings.
- B. Any material defects or damage due to shipment will be repaired or replaced by the supplier.

## **PART 3 - EXECUTION**

### **3.1 INSPECTION**

- A. The Installer shall examine substrates, supports, and conditions under which this work is to be performed and notify Contractor, in writing, of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning work means Installer accepts substrates and conditions.
- B. Notification Point: The Architect and MBTA Design and Construction Department will be given 72 hour notice to perform field inspection at the start of installation of signage. If work does not meet project requirements, contractor must remove and replace deficient work.



### **3.2 INSTALLATION/APPLICATION/ERECTION**

- A. Strictly comply with approved shop drawings and manufacturer's instructions and recommendations, except where more restrictive requirements are specified in this Section.
- B. Install LED lighting in accordance with manufacturer's instructions.
- C. Install sign plumb, level, in true plane and alignment. Provide logo sign where shown or scheduled using mounting methods indicated.
- D. Protect adjacent or adjoining surfaces and work from damage during installation in this Section.
- E. Work shall be designed and anchored so that work will not be distorted nor the fasteners overstressed from expansion and contraction of metal or other materials as applicable.
- F. Verify all electrical wiring and connections are secure and protected.

### **3.3 TOLERANCES**

- A. The following allowable installed tolerances are allowable variations from locations and dimensions indicated by the Contract Document and shall not be added to allowable tolerances indicated for other work:
  - 1. Allowable Variation from True Plumb, Level and Line: Plus or minus 1/16 inch from true position for signage smaller than 24 by 24 inches in size; plus or minus 1/8 inch from true position for signage 24 by 24 inches in size and larger.
  - 2. Allowable Variation from True Plane of Adjacent Surfaces: Plus or minus 1/16 inch.

### **3.4 CLEANING AND PROTECTION**

- A. Adjust work to present the best possible appearance. Touch-up damaged finishes and eliminate any evidence of repair. Clean exposed surfaces using materials and methods recommended by manufacturer of material or product being cleaned. Remove and replace work that cannot be successfully repaired or cleaned.
- B. Provide temporary protection to ensure work being without damage or deterioration at time of final acceptance. Remove protections and reclean as necessary immediately before final acceptance.
- C. Manufacturer shall provide Authority with information on cleaning and maintenance recommendations for logo sign.
- D. Names, stamps and decals of manufacturers, installers or maintainers of signs shall not be visible in the finished work.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 MEASUREMENT**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of MBTA Logo Lollipop Signs for the BRT Stations.

**END OF SECTION**

**SECTION 10450  
FARE COLLECTION EQUIPMENT  
PART 1 – GENERAL**

**1.01 DESCRIPTION**

- A. This Section specifies the installation of Fare Collection Equipment at all locations shown on the Contract Drawings for the Silver Line extension to Chelsea. Scheidt & Bachmann (S&B) will be responsible for manufacturing, supplying, delivering to the site, testing, and commissioning of the new fare collection equipment to be installed by the Contractor as shown on the contract drawings and described herein. The Contractor is responsible to receive, install, run conduit/cable, apply terminations, and test cable/terminations and be available as may be needed during cutover and commissioning of systems.
- B. The Fare Collection equipment to be installed at the various locations includes, but is not limited to the following:
  - 1. Cash/Credit/Debit/Full Service fare vending machines (FVMs)
  - 2. Cashless FVMs
  - 3. Fare Media Validators (FMVs)
  - 4. Networking equipment such as switches, media converters, etc.
  - 5. Any other equipment deemed necessary to complete a fully functional AFC system
- C. Work under this section also includes work under Section 16749, and 16050.

**1.02 QUALITY ASSURANCE**

- A. Maintain records of all test and inspection work securely and complete, and keep them available to the Authority during the performance of the Contract.
- B. Materials, suppliers, and products shall be subject to inspection to the extent necessary to ensure conformance to technical requirements.
- C. If any damage, defect, error, or inaccuracy is found in any material, component, or any part/parts of the work, the Engineer will have the right either to reject the work or to require correction of the work, which shall be done by, and at the expense of, the Contractor. No separate payment will be made.

**1.03 SUBMITTALS**

- A. The Contractor shall prepare and submit to the Engineer for approval, six complete sets of shop drawings with calculations stamped and signed by a State of Massachusetts Registered Structural Professional Engineer. Shop drawings shall indicate the installation of all equipment, showing locations, fasteners, reinforcements, base plates, details of fabrication, size of members, finishes and all other components that are part of the Fare Collection equipment installation as shown on the contract drawings, and reference documents supplied by the equipment supplier. Fasteners shall be checked using loading information supplied by the equipment manufacturer.
- B. Indicate by reference on the drawings the Specification Section number, title, article number and Contract Drawing and sheet number to which the shop drawing pertains. The Contractor shall not fabricate any material or proceed with any equipment installation work until approval of the shop

drawings has been obtained. Deviations from the design or reference documents as shown on the Contract Drawings shall be distinctly indicated on shop drawings. Submittal of shop drawings shall comply with the procedures included in these Specifications.

- C. Contractor shall submit their proposed delivery documentation and procedures based on information contained within these specifications.

## **1.04 DELIVERY**

- A. Shipment of the equipment from the equipment supplier's facility or from the warehouse to the installation site shall be the responsibility of the equipment supplier. The Contractor shall coordinate with the Engineer to take delivery of the Fare Collection equipment to be installed.
- B. The equipment supplier is required by MBTA to notify the Engineer at least 10 days prior to any intended shipment. The Contractor shall define details of delivery such as exact address, delivery date and time, number and type of equipment to be delivered. The MBTA engineer shall provide an onsite contact name and number to be responsible for receiving the shipment from S&B.
- C. Equipment is to be delivered to curbside of the station entrance. The delivery location is fixed unless otherwise agreed to between the Contractor, S&B, and the MBTA.
- D. The Contractor shall be responsible for all arrangements that are needed for the equipment supplier to access the delivery site and deliver the equipment. The Contractor's responsibility includes but is not limited to making the delivery area available (e.g. snow removal and free space), securing the area (e.g. posting hazard signs if necessary).
- E. The Contractor will receive the equipment securely crated and properly labeled. The Contractor and an MBTA representative shall check against the Bill of Material (BOM) against equipment received, inspect the equipment for any visible damage to packaging and crating and note any damage on the delivery receipt form.
- F. The Contractor is responsible for protecting the equipment after delivery has been made. Transportation from the delivery truck to the installation place and any associated safety precautions for drop-off, transportation and/or interim storage will be the responsibility of the Contractor. The Contractor shall adequately support, block, strap, or otherwise protect components during movement after shipment. Fare collection equipment must remain covered and protected from any environmental or construction debris while in storage awaiting installation.
- G. For equipment delivery, the equipment supplier will provide standard shipment papers to the recipient with sign-off sheets for documentation purposes. If the Contractor requires any special handling documentation, they will need to provide the pertinent information to the equipment supplier prior to shipment.
- H. The Contractor shall be responsible for providing any means or resources to protect public safety or to secure the system including those that may be needed during unloading of the truck at the curbside during delivery of the equipment as well as during the storage period prior to installation.

## **PART 2 – PRODUCTS**

### **2.01 GENERAL**

- A. Cable, conduit, and under floor duct to be provided shall be in accordance with Sections 16050 Basic Materials and Methods for Electrical Work and 16749 Fiber Optic Cable System and the cable details table provided in the S&B reference installation instructions and drawings.

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. S&B and MBTA representatives will attend site inspections conducted by the MBTA Project Manager to confirm completion of site preparation prior to equipment placement.
- B. All material and apparatus specified herein shall be installed in accordance with the Contract Documents, which include the manufacturer's instructions and recommendations, and in accordance with the Contractor's approved plans.
- C. Installation hardware to be provided by S&B includes floor anchor rods/bolts/washers, etc, supplies for leveling and sealing, insulation caps for holes in bases of FVMs that feed incoming wires where holes are not used and need to be sealed, and installation templates for all equipment types.
- D. All Fare Collection equipment shall be mounted and leveled in accordance with the S&B installation instructions and drawings.
- E. Installation hardware delivered by the equipment supplier does not include: standard tools, power supply cables to equipment, communication cables to equipment, wire raceways and tubes to the equipment for incoming power and communication cable, cables between adjacent equipment, ferrules and fiber connectors and supplies to terminate incoming power and communications cables.
- F. Contractor shall install power wiring from the power distribution panel to Fare Collection equipment, in accordance with the Contract Drawings, manufacturer's recommendations, and the requirements of these Specifications. Connections at the power distribution panel shall be made by the Contractor.
- G. Contractor will be responsible to install communications cable (Fiber Optic or CAT5/CAT6) from the fiber or network termination patch panels to the Fare Collection equipment, and the wide area network termination point within the communications room or bungalow as approved by the MBTA in accordance with Contract Drawings, manufacturer's recommendations, and requirements of these Specifications.
- H. Contractor will be responsible for termination of wiring to Fare Collection devices. MBTA representatives and Contractor will participate in startup testing to determine that all installed equipment powers up and connections are correct.
- I. The Contractor is responsible to apply cable connectors where required and shall then test cables and connectors in accordance with the applicable section of these specifications. The contractor shall submit suitable cable test reports to the Engineer.
- J. S&B shall connect test and perform final commissioning of all fare collection devices and associated equipment. Special Test Requirements for the Contractor are described within the equipment installation instructions provided herein.

### **3.02 STANDARDS**

- A. The installation of the Fare Collection equipment shall comply with:
  - 1. The applicable regulations of the Massachusetts State Building Code, Massachusetts Architectural Access Board, and the latest Massachusetts Electrical Code.
  - 2. The applicable regulations of the latest National Electrical Code.
- B. All electrical materials shall be listed by the Underwriters Laboratories, Inc. as conforming to its standards in every case where a standard has been established for the particular material type.

### 3.03 TESTING OF COMPLETED ASSEMBLIES

- A. The Contractor shall be responsible to energize all installed equipment. S&B and MBTA will commission and test for proper function and operation.
- B. The Contractor shall terminate the power and data cable provided and installed to the fare collection equipment termination points. Proper labeling of cables, connectors or conductors by the Contractor is required. S&B shall ensure that records provided by the Contractor indicate that the electrical grounding, the power cable protection and the communication capability between the data demarcation points of the field devices and the Central Computer System have been tested and documented by the Contractor prior to the commissioning.
- C. The Contractor is responsible for testing of power and communications wire and cable. All tests shall be performed in accordance with the applicable Sections of these specifications.
- D. S&B shall be responsible to perform all communications testing to confirm proper data exchange on all installed equipment, once connections are terminated.
- E. After installation of the Fare Collection equipment, the equipment supplier shall perform an Installation Inspection Test on each unit installed to confirm that the equipment is properly installed and interfaces properly with the AFC Central Computer system. All cable tests conducted by the Contractor shall be recorded and those records shall be provided to the MBTA and the equipment supplier prior to commencement of the Installation Inspection Test. S&B inspect all installed equipment for the following:
  - 1. Quality of installation
  - 2. Damage to equipment
  - 3. Missing components and parts
  - 4. Correct power and communication connections
  - 5. Correct positioning and mounting

Installations failing to meet the requirements of S&B's reference installation document shall be corrected by the Contractor at no additional cost to the Authority.

- F. The Contractor shall be available during functional testing and commissioning to correct any deficiencies that are the result of work performed by the Contractor.
- G. Commissioning of the Fare Collection equipment is the responsibility of S&B and the MBTA representatives and shall be commenced after receipt of the wiring test records from the Contractor. The MBTA shall be a witness to the Installation Inspection Test in order to avoid any doubt with respect to the cause of possible damages or inappropriate performance of work.
- H. The equipment supplier's commissioning in this context will consist of inspection of proper placement of all inner subcomponents, energizing of the equipment, function test, and communications test. The Contractor shall coordinate with the equipment supplier and the MBTA for the details of the test duration.
- I. Any system deficiencies observed under testing of the Fare Collection equipment shall be noted by the equipment supplier in the certified test report. The Contractor shall provide a new test report for repaired equipment for which the Contractor is responsible after all deficiencies are corrected and the system has been retested.

- J. The MBTA's designated representative shall witness all inspections and tests. Commissioning and Installation Inspection will be conducted in parallel therefore the availability of the MBTA's witnesses is required throughout its execution.

#### **PART 4 – MEASUREMENT AND PAYMENT**

##### **4.01 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Station. The lump sum price shall include all labor, tools and equipment incidental and necessary for the installation, complete in place, of the Fare Collection Equipment at the BRT Stations.

#### **END OF SECTION**

## **SECTION 13126**

### **PREFABRICATED BOOTHS**

#### **PART 1 - GENERAL**

##### **1.1 DESCRIPTION OF WORK**

- A. This Section specifies the following:
  - 1. Fabrication and installation of an MBTA Inspector's Booth as shown on the Plans and as described herein. The Inspector's Booth shall be a minimum of eight feet (8') long; and four feet (4') wide.
  - 2. Work of this Section also includes all glazing, doors, painting, hardware, interior finishes, security systems, electrical systems, HVAC, and millwork, for each booth and enclosure.
  - 3. Provide all security systems required for booths.
- B. Work shall include, but not be limited to, providing all materials, methods, equipment, specified herein, and installation for the complete booths and enclosures.

##### **1.2 RELATED WORK**

- A. Carefully examine all of the Contract Documents for requirements which affect the work of this Section.
- B. Other specification sections that relate directly to work of this Section include, but are not limited to, the following:
  - 1. Division 15, MECHANICAL; for HVAC unit connections.
  - 2. Division 16, ELECTRICAL; for electrical connections including conduit and wiring for power and lighting.

##### **1.3 QUALITY ASSURANCE**

- A. Source: Provide booths and enclosures that are products of one manufacturer. Provide secondary or accessory materials that are acceptable to manufacturers of primary materials.
- B. Installer: A firm that is acceptable to the manufacturer of the booths and enclosures.
- C. Coordination: Coordinate electrical and security equipment and conduit stub-up locations with requirements of Division 16 before installation of the Booth.



## **1.4 SUBMITTALS**

- A. Shop Drawings: Prepare and submit for the Engineer's approval six complete sets of shop drawings which shall indicate all materials, finishes, sizes thicknesses, joint locations, fasteners, edge supports, reinforcement angles, details of fabrication, sizes of members, sizes of glazing, electrical devices and conduits, and all other components that are part of the booth and enclosure work.
  - 1. Do not fabricate any material or proceed with any Work until shop drawings have been obtained.
  - 2. Submit shop drawings showing locations of electrical and mechanical equipment, wireway routing, and installation methods.
- B. Samples: Submit two sets of samples of all materials intended for construction to indicate type of finish and workmanship.
  - 1. Submit samples of fabrication methods.
  - 2. Provide requested sample large enough to show typical construction, finish, and workmanship.
  - 3. Submit six 1 ft. x 1 ft. samples of each armor material for testing by the Authority.

## **1.5 DESIGN STANDARDS**

- A. The requirements of this Section are based on designs as shown on the Contract Drawings and the Authority's design standards.
  - 1. The configuration of the booths and enclosures and location of principal components shall be as indicated on Contract Drawings.

## **PART 2 - PRODUCTS**

### **2.1 MATERIALS FOR CSA BOOTHS**

- A. Metals: Refer to Section 05500, MISCELLANEOUS METAL, with modifications and additional requirements as follows:
  - 1. Materials
    - a. Metals shall be free from defects impairing strength, durability or appearance and of best commercial quality for each intended purpose.
    - b. Work shall be clean, straight, and with sharply-defined profiles.
    - c. Unless otherwise noted, finished surfaces shall have a smooth satin finish.
  - 2. Fasteners
    - a. Do not use exposed fasteners on the exterior of the booths and enclosures except where shown for the roof assembly.

- b. Interior Exposed Fasteners: Provide of the same material, color, and finish as the metal to which they are applied, unless otherwise shown on the Drawings or specified.
  - c. Where corrosion-resisting metal is joined to other metals, provide corrosion-resistant fasteners and metal for welding.
- 3. Aluminum Structural and Trim Shapes: Conforming to FS QQ-A-200/9, Alloy 6063T5 trim, satin finish.
- 4. Stainless Steel: Conforming to ASTM, Type 304, 18-8 chrome-nickel alloy, No. 4 satin mill finish.
  - a. All welds required for construction shall receive matching No. 4 grind; no welds are to show on the exterior; no joints other than those shown are allowed.
- 5. Steel: Coat by hot-dip galvanizing process and passing ASTM A239.
  - a. Conform to ASTM Classifications as follows:  
Structural Steel: A36. Structural Tubing: A500, Grade B
- B. Millwork: Provide millwork as conforming to the following:
  - 1. General:
    - a. Grades of all millwork: As defined by the rules of the recognized association of lumber manufacturers producing the materials specified.
    - b. Materials for Millwork: Conform to or exceed the requirements of "Premium Grade" as established by "Architectural Woodwork Quality Standards", published by the Architectural Woodwork Institute.
    - c. Lumber and Plywood: Shall, in the raw, bear the grade and trademark of the association under whose rules it is produced, and a mark of mill identification; the material shall be made available for inspection by the Authority before finishing.
    - d. Wood for Natural Finish Millwork: Select for uniformity of color.
    - e.
 

<u>Item</u>	<u>Grade</u>	<u>Kind</u>
Plastic Laminate Countertops and Access Panels	High Density	Particleboard
Cabinets Solid Members	Clear Select	Birch
Plywood	Rotary Cut	Birch
  - 2. Plastic Laminate Countertops

- a. Pre-veneer countertops fabricated in the shop to dimensions shown.
  - b. Surfacing: 1/16 in. General Purpose Grade, Class 2 plastic laminate, satin finish.
  - c. Core: 3/4 in. high density particleboard with solid lumber edge strips as indicated on Drawings.
  - d. Backing Sheet: 0.020 in. bonded to bottom side of top to prevent moisture absorption and to minimize warpage.
  - e. All plastic laminate shall meet manufacturer's standard specification for resistance to acids, alkalies, salts, solvents, and burns.
  - f. Adhesive shall be in accordance with manufacturer's recommendations.
  - g. Color: To be selected by Engineer from manufacturer's standard range.
3. Cabinet and Casework
- a. Fabricate and install all cabinet and casework indicated on the Contract Drawings for use within the booths and enclosures.
  - b. Case Doors which are 3/4 in. thick shall have rabbeted edges; 1-3/8 in. or thicker, veneer cores; exposed edges shall have built-in or plowed-in edge bands.
  - c. Drawers: Fabricate per AWI 400-9, Premium Grade, opaque finish.
  - d. Cash Drawer: Provide stainless steel dividers per MBTA Requirements
4. Plastic Laminate Access Panels
- a. Pre-veneer panels fabricated to the dimensions shown.
  - b. Core: 1/2 in. plywood
  - c. Surfacing: 1/6 in. Vertical Grade.
  - d. Attachment of Metal Channels: Stainless steel oval head Phillips screws with collars.
  - e. The rest of the Specification shall be similar to that for plastic laminate countertops.
  - f. Color Range: To be selected by Engineer from manufacturer's standard range.
- C. Building Insulation
- 1. Provide insulation of the type indicated on Drawings. Ceiling insulation shall be 4 in. thick, "R" value of 16.5 minimum. Wall panels shall be 2 in. insulation, "R" value of 8.7 minimum.
- D. Vision Panels at Booths: Glazing shall be 1/2" nominal thickness laminated safety glass.
- E. Doors: Door assembly shall be constructed of steel, 1-3/4 in. thick with brushed satin stainless steel finish, with all welds aground smooth and filled. Provide fiberglass insulation as noted for wall panel construction. Frame to be welded integrally into booth wall. Doors shall be biparting sliding as shown with top and bottom tracks as required. Provide 1/2" laminated safety glazing in door panels as shown.
- F. Hardware: Comply with the requirements of Sections 08711, DOOR HARDWARE, except as modified herein.
- 1. Materials: All hardware shall be of the best grade materials, entirely free from imperfections in manufacture and finish.

- a. Supply all hardware with matching fasteners.
  - b. All finishes shall match satin stainless steel.
- 2. Keying Requirements: Key all locksets as directed by the Authority, match existing station keying.
  - a. All cylinders shall have removable cores.
  - b. Trim: As specified with knobs cast or forged of 0.080 wall thickness.
- 3. Manufacturers: All hardware shall be made in America and approved by the Authority.
- 4. Finish Hardware Schedule: Entry door for each booth shall have:
  - a. Hinges: Provide CBP standard #12252 continuous hinge in satin stainless steel finish.
  - b. Lockset:: Sargent #7745 mortise x KDA x US 26D with standard Ansi strike and Best Lock Co. removable core cylinder x random key.
  - c. Closer: LCN 4040 x Aluminum finish stop side mounted.
  - d. Threshold: Dorbin #79A
  - e. 2 Mop/Kick Plate
- 5. Drawers: Each drawer shall have:
  - 1 Pull, US28.
  - 1 PR Slides.

In addition to above, cash drawer is to have drawer dividers of 18 ga. stainless steel per MBTA standard.
- 6. Coat Hooks: 2 Stainless steel hooks fabricated by manufacturer of booth.
- 7. Interior Access Panel to Fare Box: Each panel shall have:
  - 1 pr. Spring Hinges, 2 in. lg.
  - 1 Transom Catch with Rim Strike
- 8. Interior Raceway Doors shall have:
  - Hidden hinges max. 16 in. o.c.
  - Security Camlock
- 9. Casework Doors: Each door shall have:
  - 1 Security Camlock
  - 2 Hinges, overlay type.
- G. Gypsum Wallboard: 1/2 in. thick, fire-rated, ASTM C36, Type X. Provide tape, joint compounds, and installation conforming to the requirements of Section 09250.
- H. Metal Ceiling: Provide 24" x 24" perforated aluminum units with color and perforation pattern selected by Engineer. Provide panels fabricated from minimum 0.040 in. thick metal. Provide ceiling panel products of one of the following manufacturers that meet or exceed the requirements of these specifications, or Engineer approved equal:

1. Simplex Ceiling Corp.
  2. Steel Ceilings.
  3. Architectural Surfaces, Inc.
- I. Resilient Flooring
1. Solid Rubber Tile: 12 in. x 12 in. x 1/8 in. thick or as indicated on the Drawings, color as selected by the Engineer.
- J. Painting: Provide painting materials that conform to requirements specified under Section 09900, PAINTING.
- K. Air Conditioning
1. Air Conditioner Unit: air cooled, 6000 Btu/H, 120 volts, located above ceiling, with access from within the booth, include a cord and plug connection to the power supply receptacle; provide air conditioner with a 1/2 in. drain line from unit, enclosed down side wall of Booth, to condensate drain line.
  2. Wiring shall include a separate wall switch, as indicated on Contract Drawings.
- L. Electric Wall Heaters
1. Heaters: Flush mounted, 1000 watts (3410 Btu/H) capacity, 120 volt, as indicated on Contract Drawings.
  2. Wiring shall include separate wall switches, as indicated on Contract Drawings.
- M. Centrifugal Exhaust Fan: 25 CFM, 120 volt, single-phase with damper.
1. As an Alternate, the exhaust fan may be incorporated into the air conditioner unit, as approved by the Engineer.
  2. Wiring shall include a separate wall switch, as indicated on the Contract Drawings.
- N. Electrical, General: Provide booths with complete interior electrical work installed as Work of this Section. Conform to applicable Sections of Division 16. Include electrical Work for the booths as indicated on the Drawings.
1. Basic Materials and Methods:
    - a. Provide empty 3/4 in. steel conduits with pull lines, as indicated on the Contract Drawings, for installation of communications equipment by others.
  2. Distribution Panelboards:
    - a. Booth shall have panelboard; 120/208 volt, three-phase, four-wire, with quantity of 12 stab-lock type molded case 20 amp circuit breakers as indicated on Contract Drawings.
    - b. Final connection and wiring to Booths electrical service shall be performed by and comply with requirements of Division 16, Electrical.

3. Booth Intercom Systems: Provide a switchable continuous communication system mounted on transparent armour panel, equal to Model No. TTU-1, as manufactured by Norcon Communications, Inc., Brooklyn, NY, to allow communication between a person in the Booth and a person immediately outside. Provide system complete and operational.
  4. Provide provisions for a Booth Security System. The booth telephone shall be fed from the alarm panel. Provisions shall be provided for connection to the Verizon demarcation from the alarm panel per Booth Security System Specification that is specified in Division 16, ELECTRICAL.
  5. Public Address System: Provide provisions for public address system interface in the Booth.
  6. Fire Alarm Pull Station: Provide provisions for fire alarm pull station in the Booth.
- O. Fluorescent Down Lights: Provide one of the following products at all locations that down lights are indicated, with an Osram D26W/41K lamp:
1. Edison Price Dark Lite DTT-26/8, 120 volts.
  2. Prescolite CF123526-462.
  3. NL RF-1211.

### **PART 3 - EXECUTION**

#### **3.1 PREFABRICATION**

- A. Metals: Specification Section 05500, MISCELLANEOUS METAL, with modifications as follows:
1. Workmanship: Metal surfaces shall be clean and free from mill scale, flare rust, and rust pitting, wellformed and finished to shape and size, with sharp lines, angles, and smooth surfaces. Weld all permanent connections. Welds shall be continuous except where tackwelding is permitted by the Authority.
  2. Use screws or bolts only where shown; where used, heads shall be countersunk, unexposed screws will be flathead, screwed up tight and threads shall be niched to prevent loosening. Exposed screws shall be stainless steel oval head Phillips Type.
  3. Thickness of metals and details of assembly and support shall give ample strength and stiffness.
  4. Provisions for Hardware and Equipment: Panels and Doors shall be prepared by manufacturer for the installation of hardware and equipment. Welding of hinges to frames will not be permitted.
- B. Millwork
1. Joints shall be tight and so formed as to conceal shrinkage. Mortise and tenon joints shall be set in glue under pressure within internal angles coped and external angles mitered. Shop miters 4 in. or greater shall be glued and dowelled or locked with a metal splice. Miters less than four inches shall be glued and splined with the spline concealed.
  2. All nail heads in finish work shall be sunk 1/16" with a nail set. Panels and siding shall be rigidly secured in place. All exposed screw holes shall be countersunk and plugged with wood. Woodwork shall be properly framed, closely fitted, and accurately set to the required lines and levels and shall be rigidly secured in place.

C. Metal Acoustical Ceiling

1. Metal ceiling shall be installed as per the manufacturer's instructions.
2. Install edge molding along perimeter and to finish off all ceiling edges.

D. Painting and Finishing Specifications Section 09900, PAINTING. Apply painting systems specified hereinbefore.

E. Modular Panel Construction

1. **General:** Booths and enclosures shall be an assembly of standardized modular panels and base and roof assemblies attached by connector bolts to adjacent panels, roof and base assemblies. Each panel shall be an independent unit which meets specific structural and operational requirements and contains specific optional equipment and associated services while maintaining ballistic integrity.
2. **Performance:** Booths and enclosures shall be capable of assembly, disassembly and relocation, and selected repairs or replacements by not more than a four-man crew and a foreman with limited hand tools. To accomplish this, booths and enclosures shall be constructed of various panels which shall independently contain, as a minimum: coin change provisions, air conditioner, electric heaters, lighting, lock security, interior/exterior communications, visual alarm, emergency lights and communications, and interior telephone connections. One panel shall provide structural support and attachment for a fare/turnstile. Other panels shall include or provide structural support for interior countertops, cash drawer, coin tray, coat hangers, communication system and control raceway and personal storage drawers, speaker and microphone housing which shall be provided as part of the Booth.
3. **Design and Construction**
  - a. **Modular Panels and Sections**
    - 1) Each integrated modular panel or roof or base section shall not exceed 500 lbs. or 7'-6" x 8" in size. Each unit will be capable of handling by a four-man crew.
    - 2) The opaque armored panel certified to meet specifications as noted in herein shall be 2" thick, constructed from Shot-Tex #1-S welded steel construction, as follows:
      - a) The exterior surface shall be a layer of Shot-Tex #1-S bullet resisting satin stainless steel wall armor.
      - b) The second layer (internal layer) shall be semi-rigid insulation 2" thick for thermal and sound insulation. Insulation shall provide an "R" factor of 8.7 minimum.
      - c) The third or interior layer, shall be shot-Tex #1-S bullet resistant stainless steel wall armor.
      - d) All layers shall be secured with Shot-Tex #1 vertical stiffener channels to form a structural panel to meet structural and low thermal conductivity requirements within the 2" thickness requirements.
      - e) The modular panels shall have watertight joints and fasteners which are accessible only from the interior. The panels shall be joined together

through bolted connections and concealed with a removable Shot-Tex #1-S bullet resistant satin stainless steel cover plate applied by hook and loop type fasteners.

- 3) Vision Panels: Install vision panels at locations indicated.
- 4) Door Panels: Install door panels and hardware as directed by manufacturer.
- 5) The modular roof shall be constructed of stainless steel sheet laminated to 3/4 in. plywood with fasteners and an internal layer of fiberglass insulation, 4 in. thick for thermal and sound insulation. Insulation shall provide a U factor of minimum 0.09. Provide fluorescent lighting and an acoustical ceiling suspended by wire supports. Support angles and flanges welded to modular panels and bolted to roof membrane shall secure roof assembly to panelized construction.
- 6) Flexible fire retardant plastic conduit shall be integral bonded in the modular panels and pre-wired to electrical outlets and switches, and communication and telephone connections. The modular panel will not contain junction boxes or internal inaccessible connections.
- 7) Coordinate with Electrical Sections and provide for emergency gate release switches and pilot lamps.

F. HVAC Installation: Install air conditioning units within booth ceilings with removable stainless steel louvers for servicing.

1. Air Conditioning

- a. Mount air conditioners above ceilings within booths at the location indicated on Contract Drawings or as directed by Engineer.
- b. Drain line running from air conditioning unit shall be connected to a floor drain provided by station contractor in a secure manner so that the line cannot be accidentally removed.
- c. Unit shall be controlled by wall switch, as indicated on Contract Drawings.

2. Electric Wall Heaters

- a. Heaters shall be controlled from wall switches, as indicated on Contract Drawings.
- b. Manufacturer shall provide two flush mounted electric heaters.

G. Electrical

1. Make provisions in pre-fabricated walls for raceways and conduits. Pre-cut electrical outlets and other required openings.
2. Distribution Panelboards
  - a. Locations of panelboards shall be as indicated on Contract Drawings.
3. Lighting: Specification Section 16500, LIGHTING.



4. Booth Intercom: Install booth intercom systems complete and operable in accordance with the following:
  - a. National Electrical Code
  - b. MBTA Manual of Guidelines and standards
  - c. Manufacturer's recommendations

#### **PART 4 - MEASUREMENT AND PAYMENT**

##### **4.1 GENERAL**

- B. Separate Measurement and Payment will not be made for the work of this Section complete in place, but all costs, therefore, shall be included in the Contract Lump Sum Price for Item No. 745.02 – MBTA Inspector's Booth.

**END OF SECTION**

## **SECTION 13127**

### **MBTA TEMPORARY COMFORT STATION**

#### **PART 1 - GENERAL**

##### **1.1 DESCRIPTION OF WORK**

- A. This Section specifies the following:
  - 4. Fabrication and installation of a temporary MBTA Comfort Station as shown on the Plans and as described herein. The Temporary Comfort Station shall be a minimum of sixteen feet (16') long; and twelve feet (12') wide.
  - 5. The Temporary Comfort Station shall include separate men's and women's toilets and wash room facilities.
- B. Work shall include, but not be limited to, providing all materials, methods, equipment, specified herein, and installation of the complete temporary comfort station.

##### **1.2 RELATED WORK**

- A. Carefully examine all of the Contract Documents for requirements which affect the work of this Section.
- C. Other specification sections that relate directly to work of this Section include, but are not limited to, the following:
  - 3. Division 16, ELECTRICAL; for electrical connections including conduit and wiring for power and lighting.

##### **1.3 QUALITY ASSURANCE**

- A. Coordination: Coordinate electrical equipment with requirements of Division 16 before installation of the Comfort Station.

##### **1.4 SUBMITTALS**

- A. Shop Drawings: Prepare and submit for the Engineer's approval six complete sets of shop drawings which shall indicate all materials, finishes, sizes thicknesses, joint locations, restroom fixtures, holding tank, electrical devices and conduits, and all other components that are part of the temporary comfort station work.
  - 3. Do not fabricate any material or proceed with any Work until shop drawings have been obtained.
  - 4. Submit shop drawings showing locations of electrical and mechanical equipment, wireway routing, and installation methods.

## **1.5 DESIGN STANDARDS**

- A. The requirements of this Section are based on designs as shown on the Contract Drawings and the Authority's design standards.
  - 1. The configuration and location of the temporary comfort station shall be as indicated on Contract Drawings.

## **PART 2 - PRODUCTS**

### **2.1 MATERIALS FOR TEMPORARY COMFORT STATION**

- A. The temporary comfort station shall consist of a two-stall restroom (one men's room and one woman's room) with the following features:
  - 6. Flushing Porcelain Toilets
  - 7. Porcelain Urinal (men's room side)
  - 8. Vanities and Mirrors
  - 9. Vanities and Mirrors
  - 10. Soap Dispensers
  - 11. Paper Towel Dispensers.
  - 12. Heating and Air Conditioning Units.
  - 13. Indoor and Outdoor Lighting
- B. The temporary comfort station shall include a Mechanical Room serving the restrooms, and include the following elements:
  - 1. Water supply or a 125 gallon (minimum) water holding tank:
  - 2. Sewer waste line or a 350 gallon (minimum) waste holding tank
- C. Exterior of Building
  - 1. Provide separate doorways with inside locks
  - 2. Occupancy light indicators
  - 3. Stairway with handrails if required.

### **PART 3 - EXECUTION**

#### **3.1 CONSTRUCTION METHODS**

- A. Construct concrete foundation pad for the temporary comfort station in accordance with the MassDOT Standard Specification Section 900 and Section 03300 – CAST IN PLACE CONCRETE, contained herein.
- B. Water and/or Sewer connections shall conform to the requirements of the City of Chelsea Department of Public Works. Holding Tanks shall conform to the relevant provisions and requirements of the Massachusetts Department of Environmental Protection.

### **PART 4 - MEASUREMENT AND PAYMENT**

#### **4.1 GENERAL**

- A. Separate Measurement and Payment will not be made for the work of this Section complete in place, but all costs, therefore, shall be included in the Contract Lump Sum Price for Item No. 746.01 – MBTA Temporary Comfort Station.

### **END OF SECTION**

## **SECTION 13700**

### **ELECTRONIC ACCESS CONTROL SYSTEM (EACS)**

#### **PART 1 - GENERAL**

##### **1.1 GENERAL DESCRIPTION**

- A. This specification section covers the furnishing, installation, configuration, and testing of an expansion to an enterprise-wide, low-voltage, access control system at four communications equipment enclosures along the Chelsea Silver Line Gateway Bus Rapid Transit (BRT) system.
- B. Contractor shall furnish and install security hardware devices, mounting brackets, power supplies, switches, controls and other components of the system as shown, and specified herein.
- C. Also furnish and install outlets, junction boxes, conduit, connectors, wiring, and other accessories necessary to complete the system installation. Requirements shall be in accordance with Division 16, Electrical.

##### **1.2 SUBMITTALS**

- A. Prior to approval of the Electronic Access Control System hardware and software components, the Contractor must submit the proposed equipment vendor's qualifications and the vendor's acknowledgement that the hardware and software to be supplied will meet all functionality required within this specification. The Contractor and vendor shall be prepared to demonstrate the equipment functionality prior to approval. The Contractor shall submit a typical site block diagram indicating hardware and software components that shall be installed at all locations.
- B. The Contractor shall have present during the duration of the Contract a certified network engineer with a minimum of 5 year's experience in networking of large-scale wide area network projects to be involved with all aspects of system integration of networked devices. The Contractor must submit this key person's resume for approval by the MBTA within 10 days from Notice to Proceed. No work shall be allowed to proceed with components having a network interface if this key person is not involved, this person shall be on-site at all times when network integration is taking place. Failure to have this person on-site shall cause the MBTA to immediately stop work until this person is on-site, at the Contractor's expense. Shall this person no longer work for the Contractor, the Contractor shall immediately inform the MBTA and a replacement shall be submitted at that time.
- C. Submit descriptive literature, including manufacturer specification sheets, for all access control equipment, software functionality, and materials proposed for use in accordance with the requirements of this Section for approval prior to fabrication, assembly, installation and testing. Also, submit the following to the Engineer for approval:
  - 1. Block diagram of complete system, illustrating proposed configuration and interconnections of all system components including, but not limited to: Access Control Panels, card readers, door monitors, request to exit devices, and audio/visual alarms.

- D. Prior to ordering any equipment required under this Section, submit six (6) copies of the following to the Engineer for approval:
1. Full technical data and manufacturer cut sheets for all equipment.
  2. Site specific plans showing details of the following:
    - a. Access Control equipment locations and mounting details.
    - b. Door hardware schedule of all Electronic Access Control doors including the following:
      - 1) Elevation drawings and operational descriptions for all electronic openings.
      - 2) Name and manufacturer of each hardware item.
      - 3) Fastenings and other pertinent information.
      - 4) Explanation of all abbreviations, symbols, and codes contained in the schedule.
      - 5) Keying information indicating clearly how the owner's final instructions on keying have been fulfilled.
    - c. Cable and conduit details.
  3. Schematic and wiring diagrams complete with terminal numbers.
  4. Procedures for programming and troubleshooting.
  5. Full interconnect diagram for overall system, including interface connections to existing equipment.
- E. Provide maintenance instruction manuals to the Engineer including information regarding installation and maintenance as follows:
1. Operational Description and Procedures
  2. Troubleshooting and Routine Test Procedures
  3. Adjustments and Alignment Procedures
  4. Wiring Diagrams, Tables and Schematics
- F. Prior to installing any equipment, submit to the Engineer for approval six (6) copies of a detailed test procedure intended to ensure all components of the system are functioning properly, in accordance with these Specifications and the Contract Drawings. The tests performed shall include, but not be limited to, the tests outlined in Paragraph 3.4 of this Section. The detailed test procedure shall include a description of all test equipment to be used and specific measurements and/or pass/fail criteria for each test.
- G. Factory Tests: Submit, at completion of factory testing, six certified copies of test results.
- H. Test Procedures and Reports: Full report details shall be submitted for the scheduled tests and the expected duration of all test procedures. All test report forms and details of the methods shall be approved before commencement of system testing to be furnished under this Contract.
1. The test report shall identify the name of manufacturer, model numbers, serial numbers, and the last date of calibration of test instrumentation. Documentation shall be furnished to verify that test instruments have been

calibrated not more than nine months prior to the tests. If a test instrument does not require calibration, it must be highlighted in the report.

2. The test report shall include a list of attendees.
3. Certified test results for the system components tests shall be submitted within 10 days after the completion of each test. No equipment shall be released for shipment until certified test data is approved by the Authority. Copies of approved test procedures, raw data measured results, calculations and all data derived from tests shall be included as part of report. All test data shall be bound in one report. The test report shall be indexed and cross-referenced in an easily understood manner.
4. Certificate of Compliance: Submit a certificate of compliance that all components furnished meet the requirements specified herein.

I. Operation and Maintenance Manuals shall submitted as listed below:

1. The Contractor shall furnish an operation and maintenance manual for each piece of equipment, unless otherwise specified herein. The manual shall be provided in both hardcopy and on compact disk. The MBTA Communications Department prior to submittal shall approve the software utilized. The following identification shall be inscribed on the cover: the words "OPERATING AND MAINTENANCE MANUAL", the name and location of the project, the name of the Contractor, and the Contract number. The manual shall include the names, addresses, and telephone numbers of each subcontractor furnishing or installing equipment. In addition, include the local representatives for each item of equipment. The manual shall have a table of contents and index. The manual shall be assembled to conform to the table of contents, including tab sheets placed before instructions covering the subject. The instruction sheets shall be legible with large sheets of drawings folded in. The contents of the manual shall also be available on-line by means of a help screens. The final Operating and Maintenance manual shall also be submitted on CD.
2. The Contractor shall submit to the Engineer for approval three copies of the preliminary operation and maintenance manual at least 30 days prior to shipment of first relevant unit.  
After approval of the preliminary submittal, and having made all necessary corrections and amendments required, the Contractor shall provide the Engineer with six (6) additional copies of the approved dated operation and maintenance manuals. One master camera-ready copy shall be included as one of the six copies to permit additional copies to be made. The master camera-ready copy shall be clearly marked as such on the outside. One manual shall be provided on compact disk. The MBTA Communications Department prior to submittal shall approve the software utilized. The manual shall provide a clear explanation of the theory, operation, and maintenance of the equipment accompanied by photos and schematic, wiring and mechanical assembly diagrams, as required. The manual shall be indexed and cross-referenced in an easily understood manner. The manual shall be loose leaf bound and shall include, but not necessarily be limited to, the following information:
  - a. Operating instructions.
  - b. Troubleshooting and fault isolation procedures for on-site level repair

- c. System equipment removal and replacement procedures.
- d. A list of the replaceable components.
- e. A test procedure to verify the adequacy of repair work.
- f. A preventive maintenance schedule and instructions for the replacement of any electrical equipment
- g. A preventive maintenance schedule for inspection, removal, and replacement for each component.
- h. A list of special tools provided by the manufacturer.
- i. A list of recommended tools and test equipment required performing all maintenance tasks.
- j. Recommended spare parts list for one year's operation.
- k. Interchangeable parts list-showing parts common to items of equipment.
- l. Equipment manufacturers' descriptive literature including catalog cuts.
- m. As-built working drawings.
- n. System component approved factory test reports.
- o. The latest service bulletins with dates that describe service procedures.
- p. Full Operations Manual for Access Control System software.

### **1.3 REGULATORY REQUIREMENTS**

A. Comply with all applicable requirements of the following:

- 1. National Electrical Code
- 2. Massachusetts Electrical Code
- 3. NFPA 130
- 4. TIA
- 5. IEEE
- 6. ADA

### **1.4 RELATED SECTIONS**

- A. See Specification Section 01010 SUMMARY OF WORK
- B. See Specification Section 16450 GROUNDING
- C. See Specification Section 16876 COMMUNICATIONS GROUNDING OF EQUIPMENT
- D. See Specification Section 16898 COMMUNICATIONS SYSTEM TESTS

### **1.5 TECHNICAL REQUIREMENTS, ELECTRONIC ACCESS CONTROL SYSTEM**

- A. General: The following information is provided to establish required system performance for the complete operating EACS security system. Some of the performance requirements noted herein are supported and supplied by existing systems in concert with new equipment and software which shall be provided by the Contractor under this scope of



work. Contractor shall provide equipment, wiring and software programming at sites as necessary to provide a complete system as described herein and as shown on the drawings.

1. The access control system components provided under this scope of work shall be compatible with the existing EACS System and shall function as an integral part thereof. The Authority's existing EACS system is a Lenel OnGuard system, providing access control and credential database services.
2. The Contractor shall be responsible for providing equipment and software to achieve the specified system performance described herein and, by reference, realize absolute and seamless compatibility with the existing Lenel system.
3. The Contractor shall ensure system additions and modifications provided under this scope of work have no negative effect on the existing systems and operations, and no permanent effect beyond that specified or implied by the scope of work unless otherwise noted herein.

B. Purpose: The electronic access control system has two major functions. The system will unlock doors after receiving a valid card read from a user with proper credentials. The system will also alert MBTA personnel if an invalid entry through a door was made.

C. Environment:

1. The system is distributed throughout station facilities, and shall also be fully integrated with the Authority's enterprise security system. Refer to the drawings and Bid Instructions to determine the scope limitations for this phase of work.
2. Central Administrative Post (Existing): The system Server is located 45 High St., Boston, Massachusetts. Primary system programming, configuration and control shall occur at this location.
3. Infrastructure and Connectivity:
  - a. Local Sites and Stations: EACS controllers shall reside on the Authority's LAN/WAN network or network segment in each region. Coordinate with the Authority on the provision of LAN ports and network rights.
  - b. Enterprise: Local LAN networks will be connected to the Security Wide Area Network (SWAN), to establish EACS connectivity between the four Chelsea Silver Line Gateway stations and the OCC. Coordinate with the Authority on the provision of IP addresses and network rights.

D. Attributes

1. General:
  - a. The EACS is the key central component for managing physical security at various MBTA sites and facilities, and will serve as the authority for establishing access rights. The system shall provide a variety of integral functions including the ability to regulate access and egress through the door ways without initiating alarms; provide identification credentials; and provide a record of the use of credentials.
  - b. The system shall be comprised of electronic access control system field devices located as shown on the drawings, and connected together to provide a complete and operational system.
  - c. The EACS shall be based on a distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment.

- d. The system shall be compliant with the existing MBTA EACS, and the credentials shall be compliant with the MBTA credentials.
  - e. The existing EACS is a Lenel OnGuard system, currently supporting hundreds of Access Control Readers, Inputs / Outputs, over 20 Client Workstations, and up to 50,000 Cardholders.
2. EACS System Description (Existing)
- a. The EACS utilizes a single seamlessly integrated relational database for all functions utilizing a fully multi-tasking multi-threading Microsoft Windows 2000/2003 or Windows XP Operating System. The EACS is written so that all modules (Access Control, Alarm Monitoring, ID / Credential Management, Visitor Management, Asset Management and Digital Video Management) are developed and built from a unified single 32-bit source code set.
  - b. The EACS software shall be written to Microsoft's published standards for User Interface Design, Secure Coding Practices and Database Implementation Guidelines (Microsoft® Open Database Connectivity (ODBC) interface).
  - c. The EACS shall be able to seamlessly interface with and monitor Controllers, reader interface modules, I/O panels, burglar alarm panels, burglar alarm panel receivers, biometric devices, personal protection devices, intercom systems, fire alarm panels (secondary monitoring only), building management systems, digital video recorders, and network video recorders.
  - d. The EACS shall be able to communicate with Controllers via RS-485, RS-232, TCP- IP/Ethernet and Dial-up via Modem.
  - e. EACS tasks shall be accessible from any compatible client workstation on the network utilizing traditional client server architecture and/or by centralized distribution (publishing) of applications using Windows Terminal Server and Citrix on Windows, Unix, Linux or Apple Macintosh based systems through any compatible internet browser application and/or by means of a mobile computing platform using a wearable computer, Tablet, Smartphone, or PDA device.
  - f. The system shall utilize an open architecture where data must reside on a single database on the EACS and must be accessible in real time to every/any EACS workstation connected to the network.
  - g. The EACS shall be able to connect to and interface bi-directionally with external data sources utilizing all of the following methods:
    - 1) ASCII with support for XML formatted text exchange of data activated both manually and automatically.
    - 2) ASCII with support for XML formatted text exchange of data using a direct table interface activated both manually and automatically.
    - 3) Real-time exchange of data via Active Directory/LDAP utilizing an API written by the EACS manufacturer. The live exchange of data shall expose EACS events and transactions to other data sources in real-time and allow for receipt of data into the EACS where this data may be acted upon and trigger linked events in the EACS in real-time.

#### E. VidSys Functionality

1. All access control doors shall trigger automatic camera(s) call-up on the Vidsys platform at predetermined VidSys client locations based on any of the following, door alarm, door forced open, door left open, valid read, invalid read. The Contractor shall coordinate in advance with MBTA on which specific client workstations where the camera(s) call up should occur. The system shall also call-up the stored image file of the card holder to allow comparison images of the card holder and live video feed to allow operator personnel to assess whether the person using the card is the card owner.
2. Each door shall be located with a geo-spatially located dynamic icon on the VidSys map screen. When the door icon is selected the operator shall be able view the doors state and to lock or unlock the door.
3. All functionality that exists for current Access Control points in the VidSys system shall also be implemented by the Contractor for the newly installed equipment, and the user interface shall match that of the existing equipment.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL REQUIREMENTS**

- A. Furnish all items of the material, design, sizes and ratings shown on the Contract Drawings and herein specified.
- B. Install ADA accepted door hardware and access control equipment and install all door hardware and access control equipment to meet ADA and AAB requirements.
- C. Product Acceptability: The Products section contains lists of acceptable products. If product substitutions are proposed, they must be made based upon a comparison of equivalence to the product specified. Considerations may include but shall not be limited to functional, physical, aesthetic and/or interface aspects. The Authority shall be the sole judge of whether or not a submitted substitution is deemed to be "equivalent" to that specified.
- D. EACS Software Functionality: The capabilities and functions described herein are capabilities of the existing software application. Contractor shall coordinate with the Authority to establish the parameters, zones, groups, and levels of use governing each software function or capability of the system, and shall configure the system to recognize and use these values. Applicable functionality that will require configuration on this project is included herein.
- E. The Contractor shall provide all licenses necessary to provide the functionality described herein.

### **2.2 MATERIAL**

- A. All material shall be new and unused and the workmanship shall be in accordance with the highest standards of the electronic equipment industry. Bids will be accepted only for new and current equipment. Equipment discontinued by the manufacturer will not be accepted. All components shall be UL listed.

- B. Equipment purchased under this Section shall comply with applicable EIA standards and the manufacturer's warranties against material and workmanship shall last for a minimum of one (1) year, following the acceptance by the MBTA.
- C. Provide equipment that meets all performance requirements when operating within the MBTA transit system environment, subject to temperature, electromagnetic interference, humidity, vibration, and light conditions typically encountered.

### **2.3 ELECTRONIC ACCESS CONTROL SOFTWARE (FUNCTIONALITY)**

- A. The EACS Software shall inherently support an unlimited number of card readers, input points, video cameras, intrusion detection points, and relay outputs. The EACS database server shall support an unlimited number of cardholders, visitors, and assets limited only by the available memory on the Controller. The database server shall also support an unlimited number of system events and System Operator transactions in the history file limited only by available hard disk space.
- B. Time Zones
  - 1. The EACS shall be capable of creating and storing up to two hundred fifty five (255) time zones. Each time zone shall have a minimum of six (6) intervals. Each interval shall be assignable to any day of the week.
  - 2. Each time zone shall be assignable to an alphanumeric name of up to 64 characters. Time zones shall be applied to access levels, card reader modes, alarm inputs, alarm outputs, and alarm masking and logging functions. Time zones shall be allowed to belong to any or all access levels so that the time zone only has to be defined once.
- C. Access Levels
  - 1. The EACS shall be capable of defining a minimum of 32,000 access levels with a minimum of 32 access levels per cardholder. Access Levels shall consist of a combination of card readers and time zones.
  - 2. Each Access Level shall be assignable to an alphanumeric name using up to 64 characters.
  - 3. Card readers shall have the ability to be assigned to any or all access levels defined in the EACS. Individual card readers shall be capable of having a distinct time zone assigned to it.
  - 4. The EACS shall allow an 'Allow User Commands' option to be assigned on a per access level basis where keypad readers are in use.
- D. Temporary Access Levels: The EACS shall be capable of assigning Temporary Access Levels inclusive of the 32,000 assignable Access Levels. Each Temporary Access Level shall be assignable to an alphanumeric name using up to 64 characters. Each Temporary Access Level shall be definable with a start and end date.
- E. Access Groups: The EACS shall be capable of assigning Access Groups with a maximum of 32 Access Levels per Access Group. Each Access Group shall be assignable to an alphanumeric name using up to 64 characters.

- F. Holidays: The EACS shall provide a minimum of 255 Holiday assignments using an embedded calendar. Holidays shall be assigned an alphanumeric name using up to 64 characters and shall be grouped into eight (8) types of holidays, and shall be assignable to individual time zones. Access rights, card reader modes, and alarm masking schedules must be able to be altered when the current date is designated a Holiday.
- G. Field Hardware Communications: The EACS shall support communication using TCP-IP protocols. Download communication between the EACS and the Controller shall be fully multi-tasking and shall not interfere with operational functions. Upon loss of communications between the EACS Server and the Controller an alarm shall be created with a time stamp. Upon re-established communication the EACS and the Controller shall automatically re-synchronize from the point of communication loss without operator intervention.
- H. Dual Path Field Hardware Communication: The EACS shall support Dual Path communications between the EACS Server and the Controllers. This shall allow for a redundant communication path in the event the primary path fails. The secondary path shall support all primary path protocols. In the event of a communication failure of the primary path the Controller shall initiate a switch over to the secondary path. During this fail over period the Controller shall periodically  
check to see if the primary path has been re-established and will automatically switch back upon a successful connection. Alarms shall be generated upon loss or restoration of communications.
- I. Global Input / Output / Event Linkage: The EACS shall support a global linkage feature whereby any input/output/event shall be linked to any other input/output/event in the EACS. Input / Output Linkages shall be able to span across Controllers. System Administrators shall be able to create global I/O function lists, each consisting of a sequence of actions to be performed, such as changing card reader modes, activating outputs, and opening or closing anti pass-back areas. Each function list may include up to six actions.
- J. Cardholder Use Limits: The EACS shall support a Cardholder Use Limit feature that shall allow System Administrators to specify the maximum number of times that a cardholder may use their credential at card readers in the facility.
- K. Device Group Support: The EACS shall support device grouping for uniform command and control of groups of devices within the system. Four types of homogeneous device groups shall be supported, including Card Reader Groups, Input Groups, Relay Output Groups, and Video Camera Groups.
- L. Scheduling Utility
1. The EACS shall provide an integral Scheduling Utility. The Scheduling Utility shall allow System Administrators to schedule actions to occur on a one-time or a recurring basis. Recurring schedules shall be configured to begin immediately, last indefinitely, or have optional start and end dates.
  2. The Scheduling Utility shall be available from both the System Administration and Alarm Monitoring modules.
  3. The types of actions that shall be schedulable include but are not limited to:
    - a. Action Group

- b. Event Archiving/Purging
  - c. Arm /Disarm Area
  - d. Start of Guard Tour
  - e. Execution of Data Exchange Scripts
  - f. Activate, Deactivate, Pulse Device Output and Device Output Groups
  - g. Global Anti-Passback Reset
  - h. Download Firmware to Controllers and IP Cameras
  - i. Download Database to Controllers
  - j. Execute Function List
  - k. Mask / Unmask Inputs, Input Groups, Alarm Mask Groups, Door Forced Open or Held Open
  - l. Open Door, Open Door Group
  - m. Change Reader Mode
  - n. Automatic Reports
  - o. Reset Use Limit
4. The Scheduling Utility shall maintain a history log in the database for actions that it executes.

#### M. Access Control

- 1. Card Reader Cipher Mode: The EACS shall support a card reader Cipher Mode that shall allow authorized cardholders to enter their Badge ID by typing it into a card reader keypad, thus emulating the presentation of the credential to the card reader.
- 2. Card Reader Time Zone Overrides: The EACS shall allow for the pre-defined default card reader settings to be overridden or temporarily changed on a time zone basis. At the beginning of the selected time zone, the selected card reader's operational mode shall be modified from its default mode to any one of the following modes: locked, unlocked, facility code, card only, card or PIN, card and PIN, card and Biometric, card or PIN and biometric, and/or card and PIN and biometric. The aforementioned options shall be available depending on the type of card reader utilized. Each card reader shall have the ability to have multiple time zone setting overrides assigned to them as required by the System Administrator.
- 3. The EACS shall allow for user definable output functionality for each card reader in the EACS.
  - a. The EACS shall allow for each card reader to be selected as either an 'in' reader, 'out' reader, or 'none' to allow for ease of reporting time and attendance basic 'time in' and 'time out' data.
  - b. Enforce Use Limit: This option shall enable Card Use Limits at the card reader limiting the number of times that cardholders may use their credential to gain access at the card reader
- 4. Real-Time, Live Video User Verification: The EACS shall have the capability of interfacing to a CCTV system and displaying a live video image next to a stored cardholder image record. This feature shall be system configurable.

5. Automatic Credential Deactivation by Lack of Use: The EACS shall have an automatic credential deactivation function where a cardholder's credential will automatically deactivate after an extended period of inactivity based upon a predetermined time period. The credential status may be reset by authorized System Operators.
  6. Automatic Credential Deactivation based upon an Event: The EACS shall have a programmable ability to deactivate an active badge based upon a pre-determined event.
- N. On-Line Context Sensitive Help: The EACS shall provide on-line context sensitive help files to guide System Administrators and System Operators in the configuration and operation of the EACS. The help menu shall be available from any window in the EACS by pressing the F1 function key or clicking on the Help icon in the toolbar. Help windows shall be context sensitive so System Administrators can move from form to form without leaving the help window. The EACS shall also come with complete on-line documentation on CD.
- O. System Downloads
1. The EACS shall provide for the downloading of data to the Controllers. Downloads shall load EACS information (time zones, access levels, alarm configurations, etc.) into the Controllers first, followed by cardholder information and card reader configurations.
  2. All Controllers on the EACS shall be downloaded simultaneously (in parallel with one another) and bi-directionally so that alarms will still report to their respective Alarm Monitoring client workstations as cardholder information is being downloaded.
  3. A complete database download of 10,000 cardholder records to all Controllers (regardless of the number of Controllers) must be complete within ten (10) minutes.
  4. Information on cardholder status, badge status, time zones or access levels shall download in real time as they are added, modified, or deleted from the EACS.
- P. Traces: The EACS shall allow for a live or historical trace on any Controller, ICM, Alarm Input, Credential (Cardholder), Intrusion Detection Device, Monitor Zone, or card reader. If applicable, the EACS shall allow for a trace on any asset, intercom, or camera. Multiple traces may be run simultaneously. The EACS shall allow System Operators to filter alarm types from the history trace window. Alarms that shall be filtered from the trace window are access granted alarms, access denied alarms, system alarms, duress alarms, and area control alarms.
- Q. Manual Control: The EACS shall provide the System Operator the option to manually control all output points and input points connected to the EACS. Control points are defined as any door relay, auxiliary card reader output, or any other relay output point of an Output Control Module (OCM).
- R. Software Upgrades: Provide software upgrades as necessary to support the hardware and functionality required for a complete and operating system as described herein and on the drawings.

- S. Licensing: Provide licenses as necessary to support the new hardware and functions required for a complete and operating system as described herein and on the drawings.

## **2.4 CONTROLLERS**

- A. The Controller shall link the EACS Software to “down-stream” field hardware components. The Controller shall provide full distributed processing of access control / Alarm Monitoring rules and operations. A fully loaded and configured Controller shall respond in less than one-half (0.5) second to grant or deny access to cardholder.
- B. The Controller shall continue to function normally (stand-alone) in the event that it loses communication with the EACS software. While in this off-line state, the Controller shall make access granted/denied decisions and maintain a log of the events that have occurred. Events shall be stored in local memory, and then uploaded automatically to the EACS database after communication has been restored.
- C. In addition, the Controller shall incorporate the following features:
1. UL 294, ULC, and CE Certified
  2. Support for Host Communications Speed of 115,200 bps.
  3. Support for Direct Connect, Remote Dial Up, or Local Area Network (LAN) Connection
  4. Support for Dual Path Host Communications - Secondary Path may be either Direct Connect, Local Area Network (LAN) Connection, or Remote Dial Up Connection.
  5. 15 MB of On-Board Memory
  6. LAN Support shall utilize RJ45 (10/100baseT) Ethernet Interface connectivity
  7. Flash Memory for real time program updates and overall host communications
  8. Support for two 2-wire downstream ports. Downstream ports shall be for connecting card readers and data gathering and output control panels via RS-485 multi-drop wiring configuration
  9. Initial base memory download between Controller with standard memory from the EACS shall require no more than ten (10) seconds
  10. Support for up to 64 downstream devices consisting of reader, relay, input, and output modules, with a maximum of 32 I/OCM devices per Controller
  11. Support of multiple card technologies
  12. Supervised Communications between Controller and EACS Software
  13. AES 128 bit Symmetrical Block Encryption conforming to the FIPS-197 standard between Controller and EACS Software communications driver.
  14. RS-485 Full Duplex, UL 1076 Grade AA communication channel to the EACS head-end
  15. Integration to other manufacturer’s card readers
  16. Uninterruptible Power Supply (UPS) with 4-hours of battery backup



17. 32-bit Microprocessor
  18. A Controller downstream serial port shall multi-drop 16 access control field hardware devices using an RS-485 UL 1076 Grade A communication format allowing a distance of 4,000 feet using Belden 9842 cable or equivalent
  19. 12 VAC or 12 VDC input power
  20. Overcurrent protection
  21. Up to Nine Digit PIN Codes
  22. Status LEDs for normal component and communication status
- D. Provide sufficient controllers, reader boards, and input and output control capacity at each controller location, to meet the requirements of the site configuration.
- E. EACS Controller:
1. Lenel OnGuard, Model LNL-3300 Controller compatible with the existing application software, with a minimum 20,000 card record capacity, power supply, battery standby, and Communications Module, as described herein. Each controller shall support up to 64 devices. No acceptable equal.
  2. Contractor shall review drawings and specifications with the Authority and Engineer, and may propose changes to the topology of the system based on device layout, where such changes improve performance or functionality of the system. The Authority has final authority as to the final approach for system topology.
  3. Controller Connectivity: Controllers shall support connection to the Authority's LAN/WAN using TCP/IP protocol. Provide an integral Ethernet network interface port for this purpose.
- F. Controller Modules
1. Dual Reader Interface Module: Lenel Model LNL-1320 Series 2, Two Reader Interface Module, compatible with the existing system and readers. No acceptable equal. Module shall support two reader portals with:
    - a. Downloadable Firmware
    - b. Eight Contact Inputs
    - c. Request to Exit Inputs
    - d. Supports 16 different card formats, including Mifare DesFire
    - e. Supports bi-directional RS-485 Open Supervised Device Protocol (OSDP) readers
    - f. Six Form-C relay outputs
    - g. RS-485 Communication to the Controller
  2. Remote Input Board: Provide Lenel Input Control Module (ICM), Model LNL-1100 Series 2, compatible with the existing system, where shown on the plans. No acceptable equal. Module shall support 16 individually programmable inputs, with 4-state supervision, and 2 individually programmable auxiliary relay outputs.
  3. Output Board: Provide Lenel Output Control Module (OCM), Model LNL-1200 Series 2, compatible with the existing system, where shown on the plans. No

acceptable equal. Module shall support 16 individually programmable, Form "C" relay outputs.

4. Controllers and modules shall be mounted within a Security Terminal Cabinet (STC). Cabinet shall be suitable for the environment in which it is installed, as recommended by the manufacturer and required by the specifications.

## **2.5 CARD READERS**

- A. Card readers shall use unique coded data stored in or on a compatible credential card as an identifier. The card readers shall be proximity type, and shall incorporate built-in heaters or other cold weather equipment to extend the operating temperature range as needed for operation at the site. Communications protocol shall be compatible with the local controller. The Contractor shall furnish card readers to read passive proximity entry cards compatible with the Authority's existing card population.
- B. Proximity card readers shall use passive proximity detection and shall not require contact with the proximity credential card for proper operation. Passive detection proximity card readers shall use a swept-frequency, radio frequency field generator to read the resonant frequencies of tuned circuits laminated into compatible credential cards. The resonant frequencies read shall constitute a unique identification code number.
  1. The reader shall have a typical read range of 5.5" to 8" when used with the compatible access card.
  2. The reader shall have a lifetime warranty.
  3. The reader shall be equipped with an internal tamper switch that shall indicate an alarm condition if an unauthorized attempt is made to disassemble the unit.
  4. The reader shall have a keypad that contains the digits zero through nine, pound, and star.
  5. The reader shall be sealed to a NEMA rating of 4X.
  6. The reader shall be UL 294 listed, and shall be FCC and DTI certified.
  7. The card readers shall include an LED. The display shall indicate power on/off, and whether user passage requests have been accepted or rejected. The reader shall have separate terminal control points for the green and red LED's, and for the audible indicator.
  8. The reader shall buffer a card read, until the controller has verified the read information can be sent up-line for processing. The response time shall be 800 milliseconds or less, from the time the card reader finishes reading the credential card until a response signal is generated.
  9. The reader shall require a one-second field clearance between card presentations, to prevent multiple reads from a single card presentation.
  10. The card reader shall be powered from the local controller and shall not dissipate more than 5 Watts.
  11. The indoor card readers shall be the HID RPK40, or approved equal, and all outdoor readers shall be HID RP40, or approved equal.

## 2.6 SECURITY TERMINAL CABINET (STC)

- A. System controllers and field control boards serving a given area shall be installed inside Security Terminal Cabinets. No controller or control module shall be mounted independently of the cabinet and its power supplies except where shown on the drawings. Refer to the drawings and the following description for details on STC construction.
- B. Provide Security Terminal Cabinets as described below, located as shown on the drawings, or at places convenient to its respective field devices. Each STC shall contain the following equipment to support the current and future alarm initiating and controlled devices to be connected at that STC location:
  - 1. STC Cabinet (Indoor/Outdoor): Stainless steel, NEMA 4X rated, hinged, three-point latch, locking handle cabinet by Hoffman or Rittal, or equal, sized to fit contents.
  - 2. STC Power:
    - a. Derive primary STC 120VAC power from a power source designated by the Authority in a secure location, or as shown on the Contract Drawings.
    - b. Power cable shall be installed in conduit.
    - c. Transformers shall be installed in locked cabinets, protected by tamper switches. Plug-in transformers that are not protected by locked cabinets are not acceptable.
    - d. Serve all low voltage powered devices within the STC and their associated powered door hardware from the Electronics Power Supply.
    - e. Provide barriers as may be necessary to separate Class I from Class II power.
  - 3. Electronics Power Supply
    - a. Ratings: Provide UL Listed Class II transformers and power supplies within the STC. Provide barriers as may be necessary to separate Class I from Class II power.
    - b. Capacity: The power supply shall be capable of powering a minimum of 125 percent of the load required at the time of acceptance (25% spare capacity).
    - c. Power Monitoring: The system shall monitor the loss and restoration of power at the STC. Loss and restoration of power shall be displayed at the console, but shall not require resetting of the system.
    - d. Battery Back-up: Provide battery back-up to retain functions of all electronics for a period of four (4) hours upon loss of 120VAC power.
  - 4. EACS Controller Board: As required for connection to access readers, locks, door position switches and egress devices associated with access controlled doors.
  - 5. STC Tamper Switch: Provide a tamper switch on the STC. Connect to the Lenel system as an individual alarm point and integrate into VidSys to alarm on triggering with video call-up of local cameras.
  - 6. Disconnect switch: Provide a disconnect switch to disconnect incoming 120VAC power in the STC.
  - 7. Terminations: Provide all connections to labeled screw barrier terminal blocks.
  - 8. Secure all devices within the STC. Dress all wiring in a neat and workmanlike manner. Label all conductors to match documentation.

9. Independent Controllers: Self-contained manufacturer's controller cabinets and field control boards which are mounted independently from the STC cabinet may be used provided they shall be considered STC's and shall meet requirements of the STC as described herein. Controller assemblies which do not of themselves meet STC cabinet requirements shall not be acceptable.

## **2.7 TAMPER SWITCH**

- A. Tamper Switches provided shall meet or exceed the following:
  1. Provide and install a reed plunger type tamper switch in each STC and SES cabinet, and connect it to the existing EACS to monitor entry to each access control panel cabinet.
  2. The tamper switch shall include an adjustable plunger, stainless steel spring and sealed plated contacts.
  3. 10 watt contact rating
  4. 200 VDC switching voltage

## **2.8 DOOR CONTACTS**

- A. All Door Contacts (magnetic door contacts) shall be SPDT magnetic switches suitable for installation on the structures and material to which they will be mounted and for the environment within which they will operate. Leads shall be mounted to conduit with sealed stainless steel strain relief connectors.
- B. Door Contacts shall internally contain resistors for use with supervisory inputs. Resistances shall be set according to the MBTA's security door standards.
- C. All Door Contacts provided shall meet or exceed the following requirements:
  1. Enclosure Die-cast aluminum or stainless steel
  2. Environmental Rating NEMA 4X
  3. Ingress protection Rating IP 67
  4. Leads Via RGS conduit or stainless steel armored cable
  5. Regulatory UL Listed

## **2.9 ELECTRIC MORTISE LOCK**

- A. All Electric Mortise Locks shall be ANSI/BHMA A156.13 Grade 1 compliant. Mortise locks shall be 24VDC fail-secure unless otherwise specified.
- B. All Electric Mortise Locks shall be rated UL 10C for positive pressure on fire doors.
- C. All exposed components of all Electric Mortise Locks shall be stainless steel construction for corrosion resistance, strength and durability.
- D. All Electric Mortise Locks shall contain an integrated request to exit sensor that shall send a signal to the EACS when the handle on the secured side of the door is used.

- E. The Electric Mortise Lock latch bolt shall always be functional by the use of the lever on the secured side of the door or by use of the key in the cylinder on the unsecured side of the door. The use of a key to open the door without a valid card read shall trigger a door forced open alarm in the EACS.
- F. The lever on the unsecured side of the door shall only move the latch bolt after the lock is powered by the EACS following a valid card read at the door.
- G. The Electric Mortise Lock shall function at operating temperatures of -31° F to 151° F.
- H. Key cylinder according to MBTA.
- I. The Contractor shall include the appropriate escutcheon to match the Electric Mortise Lock with the appropriate finish to match the existing finishes use in the station.
- J. Electric Mortise Lock shall be the Schlage L9080EU-RX, or Engineer approved equivalent.

## **2.10 DOOR CORD**

- A. Consists of an 18" or 36" armored stainless steel cable and stainless steel end pieces. Cable has an interior diameter of 0.25". Supports interior wire cables up to 0.2" thick. Door cords shall be mounted to conduit with sealed stainless steel strain relief connectors.
  - 1. Specified Manufacturers: Securitron TSB
  - 2. Approved Manufacturers: Von Duprin, Adams Rite

## **2.11 LATCH GUARDS**

- A. Latch Guards installed shall be of stainless steel and shall match the latch guards installed on surrounding doors.
- B. The Contractor shall install a Latch Guard on all Electronic Access Control doors.

## **2.12 WIRE AND CABLE**

- A. The contractor shall provide wire and cable as specified or recommended by the manufacturer. Wiring shall meet NFPA 70 and NFPA 130 standards. Cables and wiring shall be rated and approved for the intended use and environment. Cables and wires installed in stations and tunnels shall be low smoke zero halogen and wet rated.
- B. For wiring runs from the door controller to the door, a Bundled Cable shall be used.
  - 1. The Bundled Cable shall include conductors for the Electric Strike, Triple Biased Door Contact, Card Reader, and Motion Request to Exit Sensor.
  - 2. The Bundled Cable shall consist of four (4) separately jacketed multi-pairs/multi-conductors that can be peeled back from one another. The four attached multi-conductors/multi-pairs shall consist of the following:
    - a. The pairs and conductors in each multi-pair/multi-conductor shall be sized properly based on distance, signal, manufacturer recommendations or specifications, and voltage loss, but shall have the following minimum specifications:

- b. Each multi-pair/multi-conductor shall be differently colored for easy identification and shall have a rip cord and drain wire.
  - c. The Bundled Cable shall have a maximum diameter of 0.5"
- 3. The Bundled Cable shall meet or exceed the following:
  - a. Approvals: NEC CMR, CMP where required by code
  - b. Voltage Rating: 300V
  - c. Temperature Rating: 75°C
  - d. Conductor material: Bare Copper
  - e. Cable One: 22 AWG
  - f. Cable Two: 22 AWG
  - g. Cable Three: 22 AWG
  - h. Cable Four: 18 AWG
  - i. Cable One: (3) Pair
  - j. Cable Two: (2) Conductors
  - k. Cable Three: (4) Conductors
  - l. Cable Four: (4) Conductors

## **2.13 SPARE PARTS:**

- A. As described in 01010 SUMMARY OF WORK.

## **PART 3 - EXECUTION**

### **3.1 GENERAL**

- A. Installation of all Access Control System equipment and components shall be in accordance with NFPA 70, UL 681, UL 1037, UL 1076, manufacturer's recommendations, approved shop drawings, and as shown on the Contract Drawings.
- B. All wiring shall be neatly installed and wire ways shall be utilized wherever possible. All wiring shall be identified at both ends by wire markers.
- C. Furnish and install a complete and operable Electronic Access Control System.
- D. Contractor responsible for system start-up, testing and network testing.
- E. Provide incidentals and appurtenances necessary to complete the work as specified herein and as shown on the Contract Drawings.
- F. Complete as-built drawings for all work and verify that all drawings are accurate. One paper set to be provided for each Station Communication Room. One Mylar set for delivery to the Plan Room at 500 Arborway, Boston, MA 02130. One copy on Compact Disk in the latest version of AutoCAD to the Project Office.

## **3.2 INSTALLATION**

- A. Install supporting equipment in cabinets and on racks as shown on the Contract Drawings and described herein.
- B. Each Electronic Access Control component must be labeled with an ID number specified by the MBTA. The labels shall be black font on yellow background and shall be viewable for 25'. The labels shall be preprinted adhesive type and shall be rated for outdoor environment -20°F to +170°F. Labels shall be 3M or approved equivalent.
- C. The Contractor shall label each IP PoE Call Box with a label containing the following items, the Contractor shall submit an example label to the MBTA for approval prior to labeling IP PoE Call Boxes:
  - 1. 'MBTA'
  - 2. The three letter location designation
  - 3. The call box number from the Contract Drawings
  - 4. The device ID
  - 5. A QR code of the call box label information

## **3.3 SYSTEM CONFIGURATION**

- A. Configure the system to provide the following operation:
  - 1. Door Unlock Operation:
    - a. Presenting an authorized credential at a door's card reader will cause the door to be unlocked and any door alarm to be masked for a predetermined period of time.
    - b. When a person exits a door, the motion detector, integrated request to exit sensor, or push button request to exit sensor will unlock the door (if necessary) and mask door alarms for a predetermined period of time.
  - 2. Door Alarm Operation:
    - a. When a door is forced open or held open, an alarm shall be sent from the Lenel OnGuard to the VidSys system. The VidSys system shall be programmed to automatically call-up the nearby CCTV camera(s) onto the screen of the operator in charge of that location along with a description of the alarm and the recent access history, picture, and badge information of the most recent person to access the door or be denied access.
    - b. When a person is denied access a total of four or more times in a row, an alarm shall be sent from the Lenel OnGuard System to the VidSys system. The VidSys system shall be programmed to automatically call-up the nearby CCTV camera(s) onto the screen of the operator in charge of that location along with a description of the alarm and the recent access history, picture, and badge information of the person denied access.

## **3.4 TESTING**

- A. Testing shall be performed in accordance with the requirements of Specification 16898 and as described herein.
- B. Conduct electrical tests to demonstrate compliance with this Specification and with manufacturer's recommended test procedures as approved by the Engineer.
- C. The Contractor shall supply all test equipment and software for all system tests.
- D. After installation is complete, the Contractor shall verify proper operation of all system software control functions and all Access Control System components as described herein, to test all functionality of the Access Control System. The Contractor shall develop and submit a test plan for review by the Engineer 30 days prior to testing. The test plan shall contain performance and failure testing of all levels and all components within the system. The test plan must include integration of the Electronic Access Control System into the MBTA SWAN. Notify the Engineer a minimum of 14 days in advance of scheduled testing. Engineer or authorized representative reserves the right to attend and approve testing.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of the Electronic Access Control System.

## **END OF SECTION**



## **SECTION 13710**

### **IP INTERCOM PASSENGER ASSISTANCE TELEPHONE (PAT)**

#### **PART 1 - GENERAL**

##### **1.1 GENERAL DESCRIPTION**

- A. This specification section covers the furnishing, installation, configuration, and testing of IP Intercom Units (PAT) at the Chelsea Silver Line Gateway Bus Rapid Transit (BRT) system.
- B. Contractor shall furnish and install PAT devices, stanchions, mounting brackets, junction boxes, back-boxes, cabling, switches, software licenses, terminations, connections, programming and testing of the system as specified herein.
- C. Also specified herein is the programming, integration, and testing of PAT units into the VidSys System (PSIM) for camera call-up on the screen of the VidSys Client of the operator answering the calls. The MBTA currently has a Stentofon intercom system and Alphacom XE server with spare capacity that is integrated into the Lenel EACS and VidSys systems. The Contractor shall add the PAT units to the existing system, and configure the newly added PAT units to facilitate the automatic camera call up of local CCTV Cameras on answering of the incoming call. The username logged into the VidSys clients will remain constant for ease of linking of call answer to VidSys clients for camera call up.
- D. Also furnish and install other accessories necessary to complete the system installation. Requirements shall be in accordance with Division 16, Electrical.

##### **1.2 SUBMITTALS**

- A. Prior to approval of the PAT System hardware and software components, the Contractor must submit the proposed equipment vendor's qualifications and the vendor's acknowledgement that the hardware and software to be supplied will meet all functionality required within this specification. The Contractor and vendor shall be prepared to demonstrate the equipment functionality prior to approval. The Contractor shall submit a typical site block diagram indicating hardware and software components that shall be installed at all locations.
- B. The Contractor shall have present during the duration of the Contract a certified network engineer with a minimum of 5 year's experience in networking of large-scale wide area network projects to be involved with all aspects of system integration of networked devices. The Contractor must submit this key person's resume for approval by the MBTA within 10 days from Notice to Proceed. No work shall be allowed to proceed with components having a network interface if this key person is not involved, this person shall be on-site at all times when network integration is taking place. Failure to have this person on-site shall cause the MBTA to immediately stop work until this person is on-site, at the Contractor's expense. Shall this person no longer work for the Contractor, the Contractor shall immediately inform the MBTA and a replacement shall be submitted at that time.

- C. Submit descriptive literature, including manufacturer specification sheets, for all PAT equipment, software functionality, and materials proposed for use in accordance with the requirements of this Section for approval prior to fabrication, assembly, installation and testing. Also, submit the following to the Engineer for approval:
1. Block diagram of complete system, illustrating proposed configuration and interconnections of all system components including, but not limited to: PAT units, stanchions, and strobe lights.
- D. Prior to ordering any equipment required under this Section, submit six (6) copies of the following to the Engineer for approval:
1. Full technical data and manufacturer cut sheets for all equipment.
  2. Site specific plans showing details of the following:
    - a. PAT and stanchion equipment locations and mounting details.
    - b. Device schedule of all PAT components including the following:
      - 1) Elevation drawings and operational descriptions for all PAT unit locations.
      - 2) Name and manufacturer of each hardware item.
      - 3) Fastenings and other pertinent information.
      - 4) Explanation of all abbreviations, symbols, and codes contained in the schedule.
    - c. Cable and conduit details.
  3. Schematic and wiring diagrams complete with terminal numbers.
  4. Procedures for programming and troubleshooting.
  5. Full interconnect diagram for overall system, including interface connections to existing equipment.
- E. Provide maintenance instruction manuals to the Engineer including information regarding installation and maintenance as follows:
1. Operational Description and Procedures
  2. Troubleshooting and Routine Test Procedures
  3. Adjustments and Alignment Procedures
  4. Wiring Diagrams, Tables and Schematics
- F. Prior to installing any equipment, submit to the Engineer for approval six (6) copies of a detailed test procedure intended to ensure all components of the system are functioning properly, in accordance with these Specifications and the Contract Drawings. The tests performed shall include, but not be limited to, the tests outlined in Paragraph 3.4 of this Section. The detailed test procedure shall include a description of all test equipment to be used and specific measurements and/or pass/fail criteria for each test.
- G. Factory Tests: Submit, at completion of factory testing, six certified copies of test results.

H. Test Procedures and Reports: Full report details shall be submitted for the scheduled tests and the expected duration of all test procedures. All test report forms and details of the methods shall be approved before commencement of system testing to be furnished under this Contract.

1. The test report shall identify the name of manufacturer, model numbers, serial numbers, and the last date of calibration of test instrumentation. Documentation shall be furnished to verify that test instruments have been calibrated not more than nine months prior to the tests. If a test instrument does not require calibration, it must be highlighted in the report.
2. The test report shall include a list of attendees.
3. Certified test results for the system components tests shall be submitted within 10 days after the completion of each test. No equipment shall be released for shipment until certified test data is approved by the Authority. Copies of approved test procedures, raw data measured results, calculations and all data derived from tests shall be included as part of report. All test data shall be bound in one report. The test report shall be indexed and cross-referenced in an easily understood manner.
4. Certificate of Compliance: Submit a certificate of compliance that all components furnished meet the requirements specified herein.

I. Operation and Maintenance Manuals shall submitted as listed below:

1. The Contractor shall furnish an operation and maintenance manual for each piece of equipment, unless otherwise specified herein. The manual shall be provided in both hardcopy and on compact disk. The MBTA Communications Department prior to submittal shall approve the software utilized. The following identification shall be inscribed on the cover: the words "OPERATING AND MAINTENANCE MANUAL", the name and location of the project, the name of the Contractor, and the Contract number. The manual shall include the names, addresses, and telephone numbers of each subcontractor furnishing or installing equipment. In addition, include the local representatives for each item of equipment. The manual shall have a table of contents and index. The manual shall be assembled to conform to the table of contents, including tab sheets placed before instructions covering the subject. The instruction sheets shall be legible with large sheets of drawings folded in. The contents of the manual shall also be available on-line by means of a help screens. The final Operating and Maintenance manual shall also be submitted on CD.
2. The Contractor shall submit to the Engineer for approval three copies of the preliminary operation and maintenance manual at least 30 days prior to shipment of first relevant unit.

After approval of the preliminary submittal, and having made all necessary corrections and amendments required, the Contractor shall provide the Engineer with six (6) additional copies of the approved dated operation and maintenance manuals. One master camera-ready copy shall be included as one of the six copies to permit additional copies to be made. The master camera-ready copy shall be clearly marked as such on the outside. One manual shall be provided on compact disk. The MBTA Communications Department prior to submittal shall approve the software utilized. The manual shall provide a clear explanation of the theory, operation, and maintenance of the equipment accompanied by photos and schematic, wiring and mechanical assembly diagrams, as

required. The manual shall be indexed and cross-referenced in an easily understood manner. The manual shall be loose leaf bound and shall include, but not necessarily be limited to, the following information:

- a. Operating instructions.
- b. Troubleshooting and fault isolation procedures for on-site level repair
- c. System equipment removal and replacement procedures.
- d. A list of the replaceable components.
- e. A test procedure to verify the adequacy of repair work.
- f. A preventive maintenance schedule and instructions for the replacement of any electrical equipment
- g. A preventive maintenance schedule for inspection, removal, and replacement for each component.
- h. A list of special tools provided by the manufacturer.
- i. A list of recommended tools and test equipment required for performing all maintenance tasks.
- j. Recommended spare parts list for one year's operation.
- k. Interchangeable parts list-showing parts common to items of equipment.
- l. Equipment manufacturers' descriptive literature including catalog cuts.
- m. As-built working drawings.
- n. System component approved factory test reports.
- o. The latest service bulletins with dates that describe service procedures.
- p. Full Operations Manual for PAT software.

### **1.3 REGULATORY REQUIREMENTS**

A. Comply with all applicable requirements of the following:

1. National Electrical Code
2. Massachusetts Electrical Code
3. NFPA 130
4. TIA
5. IEEE
6. ADA

### **1.4 RELATED SECTIONS**

- A. See Specification Section 01010 SUMMARY OF WORK
- B. See Specification Section 13700 ELECTRONIC ACCESS CONTROL SYSTEM
- C. See Specification Section 16450 GROUNDING
- D. See Specification Section 16876 COMMUNICATIONS GROUNDING OF EQUIPMENT
- E. See Specification Section 16898 COMMUNICATIONS SYSTEM TESTS

### **1.5 TECHNICAL REQUIREMENTS FOR PAT SYSTEM**

- A. General: The following information is provided to establish required system performance for the complete operating PAT system. Some of the performance requirements noted herein are supported and supplied by existing systems in concert with new equipment and software which shall be provided by the Contractor under this scope of work. Contractor shall provide equipment, wiring and software programming at PAT sites as necessary to provide a complete system as described herein and as shown on the drawings.
1. The PAT system components provided under this scope of work shall be compatible with the existing PAT system and shall function as an integral part thereof. The Authority's existing PAT system is a Stentofon Alphacom XE system.
  2. The Contractor shall be responsible for providing equipment and software to achieve the specified system performance described herein and by reference, realize absolute and seamless compatibility with the existing Lenel EACS system.
  3. The Contractor shall ensure system additions and modifications provided under this scope of work have no negative effect on the existing systems and operations, and no permanent effect beyond that specified or implied by the scope of work unless otherwise noted herein.
- B. Purpose: The PAT system shall provide a means for passengers to communicate emergencies and requests for assistance with MBTA personnel at remote locations. The system will provide two-way voice and one-way visual communications at each BRT station platform.
- C. Environment:
1. The system shall be distributed throughout BRT station facilities, and shall also be fully integrated with the Authority's enterprise security system. Refer to the drawings and Bid Instructions to determine the scope limitations for this phase of work.
  2. Central Administrative Post (Existing): The system Server is located at 45 High St. in Boston, Massachusetts. Primary system programming, configuration and control shall occur at this location.
  3. Infrastructure and Connectivity:
    - a. Local Sites and Stations: PAT units shall reside on the Authority's LAN/WAN network or network segment. Coordinate with the Authority on the provision of LAN ports and network rights.
    - b. Enterprise: Local LAN networks will be connected to the Security Wide Area Network (SWAN), to establish PAT connectivity between the four Chelsea Silver Line Gateway stations and the OCC. Coordinate with the Authority on the provision of IP addresses and network rights.
- D. Attributes
1. General:
    - a. The system shall be comprised of PAT system field devices located as shown on the drawings, and connected together to provide a complete and operational system.
    - b. The system shall be compatible with the existing MBTA PAT, EACS, and VidSys PSIM.
    - c. The existing PAT system is a Stentofon Alphacom XE system.

- d. The existing EACS is a Lenel OnGuard system, currently supporting hundreds of Access Control Readers, Inputs / Outputs, over 20 Client Workstations, and up to 50,000 Cardholders.
- E. VidSys Functionality
  1. When a call from an IP PoE Call Box is answered by an existing IP Desktop Master Station, the associated cameras shall automatically display on the operators VidSys Client. The PAT units shall have geo-spatially located dynamic icons. When an icon is selected, the operator shall be able to select an option that will automatically initiate a call to the PAT unit attached to an IP Gateway from the IP Desktop Master Station associated with the VidSys Client.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL REQUIREMENTS**

- A. Furnish all items of the material, design, sizes and ratings shown on the Contract Drawings and herein specified.
- B. Install ADA compliant PAT units and stanchions to meet ADA and AAB requirements.
- C. Product Acceptability: The Products section lists acceptable products. If product substitutions are proposed, they must be made based upon a comparison of equivalence to the product specified, and proven interoperability with existing MBTA systems. Considerations may include but shall not be limited to functional, physical, aesthetic and/or interface aspects. The Authority shall be the sole judge of whether or not a submitted substitution is deemed to be "equivalent" to that specified.
- D. The Contractor shall provide all software and integration licenses necessary to provide the functionality described herein.

### **2.2 MATERIAL**

- A. All material shall be new and unused and the workmanship shall be in accordance with the highest standards of the electronic equipment industry. Bids will be accepted only for new and current equipment. Equipment discontinued by the manufacturer will not be accepted. All components shall be UL listed.
- B. Equipment purchased under this Section shall comply with applicable EIA standards and the manufacturer's warranties against material and workmanship shall last for a minimum of three (3) years, following acceptance by the MBTA.
- C. Provide equipment that meets all performance requirements when operating within the MBTA transit system environment, subject to temperature, electromagnetic interference, humidity, vibration, and light conditions typically encountered.

### **2.3 SYSTEM DESCRIPTION**

- A. PAT units shall be IP Power over Ethernet (PoE) units.
- B. PAT units shall be installed in free-standing weatherproof stanchions with integrated lighting and strobe indicators.

- C. PAT units shall be flush mounted, tamper and weather resistant, and located as required for direct access calling to masters, as shown on the plans.
- D. Each PAT unit shall be programmed to call a specific master station(s). Pressing button on substation shall provide call request verification by blinking LED on station. A substation “call-request” call shall be identified on a display master, with text message, or flash an LED and sound a ringing tone on a master station.
- E. Once call connection is established, normal conversation shall take place in the “duplex” mode, whereby each person may talk “hands-free.”
- F. Active Noise Cancellation shall be provided at the PAT unit. PAT units shall use an advanced signal processing algorithm to identify and filter out background repetitive noise signal audio. The feature shall be integrated into the PAT unit onboard DSP and software adjustable from the PAT unit integrated web server.
- G. IP networking and security shall be provided at the PAT units. PAT units shall have the IEEE 802.1X standard for port-based Network Access Control which provides an authentication mechanism to devices that need to attach to the LAN. It either establishes a point-to-point connection on authentication or it prevents such a connection if the authentication fails.

## **2.4 IP PoE PASSENGER ASSISTANCE TELEPHONE (PAT)**

- A. The PAT intercom shall meet, or exceed, the following specifications:
  - 1. The IP PoE PAT shall be flush mount in stanchion, unless otherwise noted.
  - 2. Faceplate design shall be vandal resistant, corrosion resistant stainless steel construction.
  - 3. Loudspeaker, microphone, call buttons and tamperproof fasteners shall be vandal resistant and composed of corrosion resistant materials.
  - 4. The IP PoE Call Box front plate shall match that of the existing call boxes with dual buttons. One button shall say “PUSH FOR INFORMATION INTERCOM ONLY” and the other “PUSH FOR EMERGENCY” to make it clear to the user what each button is used for. Each button shall call a different set of phones based on the MBTA protocols, coordinate calling and call sequencing with the MBTA.
  - 5. Above the “PUSH FOR INFORMATION ONLY” button shall be Braille for “INFO” and above the “PUSH FOR EMERGENCY” button shall be Braille for “POLICE”.
  - 6. Programmable relay output for lock control or auxiliary device.
  - 7. IP PoE Call Box shall connect using a RJ-45 10BASE-T/100BASE-TX PoE connector for signal and power requirements.
  - 8. The IP PoE Call Box shall accept Power over Ethernet (PoE) IEEE 802.3af, Class 0, unless otherwise specified. Contractor shall provide a compatible PoE network switch, as required to power Ethernet devices.
  - 9. The IP PoE Call Box shall be fully compatible with the existing Stentofon system.
  - 10. Audio technology capabilities and features shall include:
    - a. Wideband 200 Hz – 7 kHz (G.722).
    - b. Telephony 3.4 kHz (G.711).
    - c. Speakerphone output: 1.5 watts.
    - d. Acoustic Echo Cancellation.
    - e. Open Duplex.

- f. Adaptive Jitter Filter.
- 11. Advanced operational features shall include, and not limited to:
  - a. Network Supervision.
  - b. Voice over IP Statistics.
  - c. Centralized Monitoring.
  - d. Tone Test.
- 12. Installation features for intercom substation shall include:
  - a. Dual Ethernet Ports.
  - b. Remote Software Upgrade.
  - c. Centralized Provisioning.
  - d. DHCP and Static IP settings.
  - e. Integrated Web Server.

## **2.5**

### **PAT STANCHION**

- A. PAT stanchions shall be free-standing units constructed of .25" steel with multi-coat rust inhibitive coating.
- B. PAT stanchion dimensions shall be 6'H x 10"W x 8"D.
- C. PAT stanchions shall include hardware for mounting in concrete foundation.
- D. PAT stanchions shall include an integrated blue light/strobe mounted at the top of each stanchion. The blue area light shall be continuously lit to indicate the location of the PAT unit. A 1.5 candlepower (minimum) strobe shall activate when a PAT unit call is activated.
- E. The PAT stanchion shall have a weather resistant blue finish.

## **2.6**

### **SPARE PARTS:**

- A. As described in 01010 SUMMARY OF WORK.

## **PART 3 - EXECUTION**

### **3.1**

#### **GENERAL**

- A. Installation of all Access Control System equipment and components shall be in accordance with NFPA 70, UL 681, UL 1037, UL 1076, manufacturer's recommendations, approved shop drawings, and as shown on the Contract Drawings.
- B. All wiring shall be neatly installed and wire ways shall be utilized wherever possible. All wiring shall be identified at both ends by wire markers.
- C. Contractor shall be responsible for system start-up, testing and network testing.
- D. Provide incidentals and appurtenances necessary to complete the work as specified herein and as shown on the Contract Drawings.
- E. Complete as-built drawings for all work and verify that all drawings are accurate. One paper set to be provided for each Station Communication Room. One Mylar set for delivery to the Plan Room at location to be determined by the MBTA. One copy on Compact Disk in the latest version of AutoCAD to the Project Office.



### **3.2 INSTALLATION**

- A. Each PAT unit must be labeled with an ID number specified by the MBTA. The labels shall be black font on yellow background and shall be viewable for 25'. The labels shall be preprinted adhesive type and shall be rated for outdoor environment -20°F to +170°F. Labels shall be 3M or approved equivalent.
- B. The Contractor shall label each IP PoE Call Box with a label containing the following items, the Contractor shall submit an example label to the MBTA for approval prior to labeling IP PoE Call Boxes:
  - 1. 'MBTA'
  - 2. The three letter location designation
  - 3. The call box number from the Contract Drawings
  - 4. The device ID
  - 5. A QR code of the call box label information

### **3.3 SYSTEM CONFIGURATION**

- A. Emergency IP Call Box System Operation
  - 1. The new IP PoE Call Boxes and IP Desktop Master Stations shall be configured in the existing Stentofon Alphacom XE server and integrated into VidSys to be used for camera call up on the screen of the operator when they answer the call from the IP PoE Call Box.
  - 2. The Contractor shall associate up to four CCTV cameras nearby the IP PoE Call Boxes so that they are automatically displayed on the VidSys Client of the answering operator. The Contractor shall select a layout that is appropriate to displaying the number of associated CCTV camera streams.
  - 3. The IP PoE Call Boxes and IP Gateways will call different IP Master Stations based on the button pressed. If the call is not answered after a specified number of rings, the IP PoE Call Box or IP Gateway will call another IP Master Station. The dialed IP Master Stations and call sequencing is based on MBTA protocols for different button presses and call box types. Coordinate IP Master Stations called and call sequencing with the MBTA.

### **3.4 TESTING**

- A. Testing shall be performed in accordance with the requirements of Specification 16898 and as described herein.
- B. Conduct electrical tests to demonstrate compliance with this Specification and with manufacturer's recommended test procedures as approved by the Engineer.
- C. The Contractor shall supply all test equipment and software for all system tests.
- D. After installation is complete, the Contractor shall verify proper operation of all system software control functions and all Access Control System components as described herein, to test all functionality of the Access Control System. The Contractor shall develop and submit a test plan for review by the Engineer 30 days prior to testing. The test plan shall contain performance and failure testing of all levels and all components

within the system. The test plan must include integration of the Electronic Access Control System into the MBTA SWAN. Notify the Engineer a minimum of 14 days in advance of scheduled testing. Engineer or authorized representative reserves the right to attend and approve testing.

#### **PART 4 - MEASUREMENT AND PAYMENT**

##### **4.1 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of the Passenger Assistance Telephone system.

**END OF SECTION**

## **SECTION 16050**

### **BASIC MATERIALS AND METHODS FOR ELECTRICAL WORK**

#### **PART 1 - GENERAL**

##### **1.1 DESCRIPTION OF WORK**

- A. This Section specifies basic materials and methods for electrical work.
- B. The work under this Section shall include furnishing all labor, materials, equipment, tools, transportation and services necessary to construct and install and complete conduit and wiring system and other work as shown on the Contract Plans and specified herein. This shall include, but not be limited to, all excavation, backfilling, conduit, wiring, fasteners, splices, terminal connectors and all incidentals necessary to provide a complete system.
- C. All work performed and all materials furnished shall be in reasonably close conformity with the dimensions, details, physical and chemical characteristics and other specific requirements of the contract. Where the terms "in conformity with," "in agreement with," "in compliance with," or terms of like exactness occur in these Specifications, they shall be construed to mean "in reasonable close conformity with."

Due to the continuous and rapid changes experienced by the electrical industry, minor deviations in electrical materials or methods from those specified herein will be acceptable provided that the materials or methods are equal to or better than those originally specified, the functional requirements of the specifications are met, and the materials or methods are accepted standards in the electrical industry at the time this contract is executed.

- D. Excavation for placing or construction of any of the items shall be made to the minimal practicable limits. Where, in the opinion of the Engineer, the base on which an item is to be founded is unsuitable, as a foundation, the Engineer may direct further excavation and backfilling with gravel borrow to the elevation of the proposed base of the foundation.

Where rock is encountered in the course of excavation, only the rock that will interfere with proper placing of the item shall be removed. Backfill, in general, shall be with the material obtained from the excavation, compacted in layers not exceeding six inches in depth before compaction.

- E. Wherever in the course of operation it is necessary to temporarily remove parts of existing facilities or other construction in order to do the directed work, the Contractor shall finally replace and restore the construction in kind. Separate payment will not be made for the components of the work for which such removals are made but all associated costs shall be included in the lump sum costs and shall be considered incidental to the items of work to which they pertain.
- F. The Contract price for the lighting system as described hereinafter and as listed in the proposal includes all materials complete in place as part of the entire system, whether the component parts of the system are specifically mentioned or whether they are implied by the nature and satisfactory operation of the system.

For example, all appurtenances implied under "fixture" (e.g., luminaires brackets, ballast,

photocell, etc.) are included in the contract lump sum price for the system. This example is not restricted to fixtures; it is applied equally and similarly to all items. Fuses and circuit breakers are considered as part of the item in which they are placed.

## **1.2 REFERENCES**

A. Comply with applicable requirements of the following:

1. National Electrical Code
2. Massachusetts Electrical Code

## **1.3 SUBMITTALS**

A. Submit shop drawings for review showing fabricated work being furnished and installed under these Specifications. Submit such drawings prior to fabrication and within ample time to prevent delays in the work.

B. Submit verified test results to the Engineer promptly upon completion of test.

C. Before installation of the wire and cable, submit the following information for each type and size of wire and cable for review:

1. Manufacturer of the wire and cable.
2. Number and size of strands composing each conductor.
3. Conductor insulation composition and thickness in mils.
4. Average overall diameter of finished wire and cable.
5. Minimum insulation resistance in megohms per 1000 feet at 20°C ambient.
6. Jacket composition (if any) and thickness in mils.
7. Total number of conductors per cable.
8. Shield material (if any) and thickness.
9. Conductor resistance and reactance in ohms per 1000 feet at 20°C ambient.
10. Conductor ampacity at 20°C ambient.

D. Prior to installation of any wires, factory certified test reports shall be submitted to the Engineer for approval. The tests shall include, but not be limited to, dielectric withstand and insulation resistance tests as specified under U.L. Standard U.S.-44 "Rubber Insulated Wire and Cable" or U.L. Standard U.S.-83 "Thermoplastic Insulated Wires."

E. Within 30 days following execution of the Contract and prior to ordering the area lighting poles, luminaires, and wiring from the manufacturer, the Contractor shall visit the project site and become familiar with all aspects of the proposed lighting system. Shop drawings shall then be submitted to the Engineer for approval in accordance with the Standard Specifications. The shop drawings submitted for approval shall include poles, luminaires, lamps, brackets, all wires, and cables, splicing materials, pull boxes, junction boxes, foundations, conduit and fittings, panel boards, contactors, wire ways, cabinet and components, aerial cable and messenger wire, wood poles, wood pole fittings, wood pole hardware, brackets, guy wires, butt support poles, ground rods, ground wire, ground connectors, clamps and components, etc.

F. No work shall be commenced by the Contractor until he has approval of the drawings in writing from the Engineer. Approval of these drawings will be general in character and shall not mean that the drawings have been checked so as to relieve the Contractor from the responsibility of or the necessity of furnishing materials and workmanship required by the plans and these

specifications.

- G. The Contractor shall order all materials required for the work immediately after approval by the Engineer in order to avoid undue delay in the performance of the work.
- H. The Contractor shall deliver to the engineer a certificate of compliance by the manufacturer for all materials purchased from the manufacturers.
- I. General bulletins or catalogs will not be accepted as shop drawings unless the equipment on which approval is to be obtained is specifically marked and information pertaining to the item including dimensions where required for installation, is included. These types of documents shall be certified for construction.
- J. The Contractor shall provide the MBTA with signed affidavits from a master electrician licensed by the Commonwealth of Massachusetts, who has supervised such electrical installations on a regular basis, stating that the installation is in compliance with the Massachusetts Electrical Code.

#### **1.04 REGULATORY REQUIREMENTS**

- B. The Contractor shall comply with the requirements of all national, state and local codes, laws and ordinances, and all rules and regulations of public administrative authorities having jurisdiction over the work where the requirements do not conflict with these Specifications.
- C. The latest published issues of the standards, codes, recommendations or requirements of the following listed organizations in effect at the date of the Notice-to-Proceed where the requirements do not conflict with these Specifications. In case of a conflict, the more stringent shall apply.

AASHTO	American Association of State Highway and Transportation Officials
ANSI	American National Standards Institute
AWS	American Welding Society
ASTM	American Society for Testing and Materials
ICEA	Insulated Cable Engineers Association
IEEE	Institute of Electrical and Electronic Engineers
MEC	Massachusetts Electrical Code
NEC	National Electrical Code
NEMA	National Electrical Manufacturer's Association
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
UL	Underwriter's Laboratories, Inc.

- D. All work shall be performed by electricians licensed in the Commonwealth of Massachusetts and who will work in harmony with the Authority's work forces.

#### **1.05 DESIGN REQUIREMENTS**

- A. The Contractor shall perform the detailed design based on the concepts as shown on the Contract Drawings and as described in respective Sections of these Specifications. The Contractor shall

apply the concept conveyed by the typical design to the final detailed design, making changes as required to make his system work as intended.

#### **1.06 SAFETY PRECAUTIONS**

- A. The Contractor shall furnish, place and maintain proper safety guards for the prevention of accidents that might be caused by the workmanship, materials, equipment or electrical systems installed or furnished by him.
- B. The Contractor shall furnish, install and maintain all necessary temporary construction required to secure the safety of life, limb and property, from an electrical accident, during the course of construction.
- C. All safety precautions of the electrical systems, electrical equipment and of the installation made by the Contractor shall be maintained until all possible electrical hazards have been eliminated by the progress of construction

#### **1.07 QUALITY ASSURANCE**

- A. It shall be the Contractor's responsibility to repair or replace any equipment damaged by his forces prior to final acceptance by the Engineer, at no additional cost to the Authority.
- B. Cable and equipment acceptance testing shall be performed by an independent NETA certified testing agency.

#### **1.08 JOB CONDITIONS**

- A. The information on the Contract Drawings describing the existing electrical facilities pertinent to this Contract insofar as it is shown. The Authority does not guarantee or represent that the existing electrical facilities conform to the Contract Drawings. It shall be understood that conditions may exist which are contrary to the conditions indicated by the existing Drawings and that the Contractor assumes all risks regarding the cost or quantity of the work to be done because of any use which he may make of them. The Bidder shall visit the site and satisfy himself by visual inspection alone, as to the existing conditions. No claim for extra cost will be allowed by the Authority because of the Contractor's unfamiliarity with observable site conditions.
- B. The Contractor shall assume the cost of and the entire responsibility for all changes in the work as shown in the Contract Drawings which may be required by approval of materials and equipment other than those specified. This cost and responsibility shall also encompass all work performed prior to the written acceptance of submittals by the Engineer.
- C. Approval of materials and equipment shall be based on manufacturer's published ratings. Any materials or equipment listed, including sizes, which are not in accordance with the Specification requirements and that have not been submitted for approval, may be rejected and the Engineer shall then have the right to select materials and equipment therefore.
- D. Before installing any of the electrical work, the Contractor shall see that it does not interfere with the clearances required for finished installation. Installed work which interferes with other work shall be changed as directed. All costs incidental to such changes shall be borne by the Contractor at no additional expense to the Authority.

- E. During the construction period, the Contractor shall adequately protect all electrical equipment and materials against damage and shall replace all damaged and defective electrical materials and equipment.
- F. All exposed surfaces, including panels, apparatus, lighting fixtures, lenses, lamps, devices, device plates, and all other electrical equipment shall be thoroughly cleaned

## **PART 2 - PRODUCTS**

### **2.1 GENERAL REQUIREMENTS**

- A. Furnish all items of the materials, design, sizes, and ratings shown on the Contract Drawings and herein specified.
- B. Furnish materials and equipment bearing evidence of UL listing where UL standards exist and such product listing is available.
- C. Methods of fabrication, assembly and installation are optional unless otherwise specifically indicated.
- D. Provide products that are free from defects impairing performance, durability, or appearance, and of the commercial quality best suited for the purpose shown on the Contract Drawings or specified herein.
- E. Steel conduit and accessories specified to be zinc coated: Hot-dipped galvanized after fabrication in accordance with ASTM A286.
- F. Conform to applicable requirements of Insulation Power Cable Engineers' Association (IPCEA).
- G. All equipment, devices, materials, etc. shall be new and capable of integration into the system and subsystems specified within these Specifications.
- H. The material and apparatus required for the work to be performed is specified within the respective Sections of these Specifications.

### **2.2 RIGID GALVANIZED STEEL CONDUIT AND ACCESSORIES**

- A. Conduit, couplings, elbows, bends, and nipples: ANSI C80.1 and UL 6, with each length bearing manufacturer's stamp and UL label.
- B. Method used to determine the thickness of zinc coating: The Referee Test included in the appendix to ANSI C80.1.
- C. Fittings and Accessories:
  - 1. Galvanized steel or malleable iron, ANSI C80.4.
  - 2. Provide separable watertight hub fittings with a gasket, separate nylon insulated throat and a case hardened locknut.
  - 3. Bushings: Nylon insulated metallic and grounding type.
  - 4. Furnish conduit straps, clamps, and clamp backs made of galvanized malleable iron.

- D. Conduit shall be rigid galvanized steel, size as shown on the drawings. Electrical Metallic Conduit (EMT) is not allowed.

### **2.3 PVC ELECTRICAL CONDUIT AND FITTINGS (ONLY FOR OUTDOOR USE)**

- A. Heavy wall, high impact strength, rigid PVC conforming to the requirements of EPC-40-PVC conduit of NEMA TC2 and fittings for EPC-40-PVC conduit of NEMA TC3.
- B. UL listed in accordance with Article 347 of the NEC for underground and exposed use.
- C. Flammability rated as self-extinguishing, and having the following minimum properties:
  - 1. Tensile strength, ASTM D638 at 78°F: 6,000 psi.
  - 2. Flexural strength, ASTM D790: 11,000 psi.
  - 3. Compressive strength, ASTM D695: 8,500 psi.
  - 4. Hardness (Durometer D), ASTM D2240: 77.
  - 5. Water absorption, percent maximum, in 24 hours at 72°F. ASTM D570: 0.03.
  - 6. Dielectric strength, volts per mil, ASTM D149: 1,100.
  - 7. Thermal conductivity: 1.3 BTU per square foot per degree F per inch.
- D. Use 2" and 1 1/2" inside diameter Schedule 40 PVC for concrete encased PVC conduit, size as shown on the drawings. Rigid Galvanized Steel conduit sweeps to be used rising to above grade from below grade concrete encased PVC conduit.

### **2.4 CONDUIT EXPANSION FITTINGS**

- A. Fabricate from material similar to the type of conduit with which they are to be used.
- B. Include a factory installed packing ring, designed to prevent the entrance of moisture, and a pressure ring.
- C. Also include a grounding ring or a grounding conductor for metallic expansion couplings.

### **2.5 MULTIPLE PIPE HANGERS (TRAPEZE TYPE)**

- A. Fabricate of two or more steel hanger rods, a steel horizontal member and all U-bolts, clamps, and other attachments necessary for securing hanger rods and conduits.
- B. Hanger Rod: Not smaller than 3/8 inch diameter, threaded either full length or for a sufficient distance at each end to permit at least 1-1/2 inches of adjustment.
- C. Horizontal Member
  - 1. Standard structural steel shapes such as angles or channels, 1-1/2 by 1-1/2 or 1-5/8 by 1-5/8 inches, 12 gauge, cold-formed, lipped channel, and designed to accept special spring-held hardened steel nuts for securing hanger rods and other attachments.
  - 2. Two or more channels may be welded together to form horizontal members of greater strength than single channels.
  - 3. Galvanize after fabrication.
- D. Design



1. Capable of supporting a load equal to the sum of the weights of the conduits and wires, the weight of the hanger itself, plus 200 pounds.
2. The stress at the root of the thread of the hanger rods; not more than 9,475 psi at design load.
3. Size the horizontal member such that the maximum stress will be not more than 12,650 psi at design load.

## **2.6 INSERTS**

- A. Channel Inserts. Fabricate from not less than 12 gauge steel channel having an overall size of 1-1/2 by 1-1/2 or 1-5/8 by 1-5/8 inches with continuous 7/8 inch wide slot, in lengths as indicated. Galvanize after fabrication.
- B. Channel Inserts for Embedding in Concrete
  1. Fabricate from channels having a solid base.
  2. Weld concrete anchors to the channel during fabrication and before coating.
  3. Galvanize after fabrication
  4. Provide assemblies with a minimum pull-out load rating of 4,500 pounds per linear foot uniformly distributed.
  5. Furnish all channel inserts for installation embedded in concrete with the channel interior completely filled with styrofoam to prevent seepage of concrete into the channel during installation.
- C. Channel Inserts for Surface Mounting
  1. Fabricate from channel having 3/8 inch by 3-inch slots on 4-inch centers in the base.
  2. Galvanize inserts for surface mounting on concrete surfaces or for installation in damp or wet areas.
- D. Spot Inserts for Embedding in Concrete
  1. Steel, galvanized after fabrication
  2. Designed for a maximum loading of 800 pounds with safety factor of three.
  3. Knockout openings to accommodate either square or rectangular nuts.

## **2.7 SURFACE METAL RACEWAYS AND FITTINGS**

- A. ANSI/UL 5 and the NEC.

## **2.8 OUTLET, JUNCTION AND PULL BOXES**

- A. Conform to NEC Article 370. Electrical boxes shall conform to UL-50, "Standard for Electrical Cabinets and Boxes", and UL-514, "Standard for Electrical Outlet Boxes and Fittings".
- B. Provide electrical boxes of the material, finish, type and size indicated and required for the location, kind of service, number of wires, and function. Boxes shall have mounting holes retapped for 10-24 machine screws.
- C. Provide boxes complete with accessible covers designed for quick removal and suitable for the purpose for which they will be used, except that boxes in which or on which no devices or

fixtures are to be installed, shall be equipped with flat or raised blank covers as required. All ceiling fixture outlet boxes shall be equipped with 3/8-inch boltless fixture studs.

- D. Boxes not over 100 cubic inches in size shall be cast. Boxes over 100 cubic inches in size shall conform to the requirements for cabinets.
- E. Covers: Same thickness as boxes and secured in position by means of No. 10-24 stainless steel machine screws. Arrange covers to be readily and conveniently removed.
- F. Coat junction boxes inside and outside to prevent oxidation. Where outlet boxes are used as junction boxes they shall be cast aluminum and not be smaller than 4 inches square by 1-1/2 inches deep. Provide such boxes with flat blank covers.
- G. Outlet Boxes: Cast aluminum, not be smaller than 4 inches square by 2-1/8 inches deep.
- H. Concealed Switch Boxes: Cast aluminum, not less than 4 inches square by 1-1/2 inches deep for two devices unless otherwise indicated. Provide covers with rectangular openings of proper size and shape. Furnish and install special boxes required to suit the kind of service and location requirements, as indicated, and as may be directed by the Engineer.
- I. Cast metal boxes shall be of aluminum alloy, with compatible conduit fittings.
- J. Boxes for exposed switches and receptacles: Cast metal, FS and FD Types.
- K. Furnish brackets, supports, hangers, fittings, bonding jumpers and all other accessories required.
- L. Provide neoprene gaskets 1/8 inch thick with boxes subjected to weather, and as directed by the Engineer.
- M. Grounding. Provide each box to which a lighting fixture or receptacle is to be attached with a grounding terminal.
  - 1. Grounding Terminal: Either a green-colored washer-in-head machine screw not smaller than No. 10-32 in a drilled and tapped hole in the back of the box, or a grounding bushing with green-colored machine screw terminal attached to one of the conduits.
  - 2. Provide suitable grounding terminals in motor connection boxes.
  - 3. Install grounding jumpers as specified in Section 16450 - GROUNDING.
- N. Junction and pull boxes must be surface mounted and not buried.

## **2.9 CABLE TRAYS**

- A. General. Provide cable tray systems conforming to the requirements of NEMA VE1, except for modifications indicated. Cable tray system shall be designed to withstand Seismic Zone 3 earthquake.
- B. Cable Tray System Components: Hot-dipped, galvanized steel with PVC coating; or, stainless steel.
  - 1. Hot-dipped galvanized after fabrication in accordance with ASTM A 386. PVC coating of 20 mils minimum having Shore A durometer hardness of 75.
  - 2. Stainless steel as indicated.
- C. Dimensions

1. Straight sections and fittings: Inside clear width as indicated, measured between the rails. Overall width not exceeding inside depth by more than 2-1/2 inches. Inside nominal depth: 4 inches. Overall tray depth not exceeding inside depth by more than 3/4 inch.
2. Rung spacing for ladder-type straight sections: 9 inches on centers maximum.

D. Fabrication

1. Straight sections and fittings consisting of stiffened channel rungs located between channel-shaped side rails having outward projecting flanges.
2. Straight-section side rails shall have a top flange at least 1-1/4 inches wide and minimum 3/8-inch vertical stiffening lip.
3. Rungs shall be positioned to provide a flat, cable support surface at least 1-1/8 inches wide, excluding corner radii, and shall be 0.060 inch thick. MIG-weld rungs to side rails and clean welds.

E. Test Requirements

1. Cable tray system shall be capable of supporting a total cable load of 55 pounds per linear foot on a maximum span of 8 feet with a safety factor of 2 based on the destructive load, regardless of the type of splice plates or type of span, when tested in accordance with load test procedure described in NEMA VE1.
2. Straight sections and fittings shall not permanently deform under a 202 pound static concentrated load applied vertically along a 4-inch length for both of the following conditions:
  - a. Load applied to one side rail of tray section having specified cable load and support spacing. Load shall be applied at midpoint between supports over a splice connection.
  - b. Load applied to one rung of empty tray section having specified support spacing. Load shall be located at midpoint between side rails and supports. Cable tray support shall be capable of supporting 0.625 of the sum of the total load on both spans adjacent to support with safety factor of 2.

## 2.10 CABLE TRAY CHANNEL SUPPORTS

- A. Fabricate from minimum 12 gauge steel channel, 1-5/8-by-1-5/8 inches, with a continuous 7/8-inch wide slot. Hot-dipped galvanized.
- B. Hardware, Fittings, and Brackets: Zinc or cadmium coated.
- C. Design assembled supports, fittings, brackets, and hardware to carry the loads shown on the Contract Drawings with a factor of safety of three or greater.
- D. Supports shall provide at least 1-1/8 inch bearing length for each rail and shall have provision for tray hold-down clamps and fasteners.

## 2.11 UNDERFLOOR DUCTS, TRENCHES, AND FITTINGS

- A. Manufacture ducts and trenches from 14 gauge galvanized steel, furnished with a UL listed corrosion-resistant coating.
- B. Design fittings for use with the duct or trench to form a complete underfloor raceway system.

- C. Ducts for Power Service: 3-1/8 inches wide by a minimum 1-1/4 inches deep, or 6 inches wide by 1-1/2 inches deep, as indicated, with threaded 2 inch IPS inserts spaced on 2-foot centers.
- D. Ducts for Low Voltage, Communication, or Signal Use; Six inches wide by 1-1/2 inches deep with 2-inch IPS inserts spaced on 2-inch centers.
- E. Floor Trenches: 18 inches wide by 4 inches deep with 5/16-inch thick floor plate. Cover plates of maximum length, as indicated.
- F. Equip inserts with caps and countersunk-head floor marking screws.
- G. Size junction boxes for underfloor ducts to accommodate the ducts, and finish similar to the duct.
- H. Provide approximate tile holders of a depth as required for installation of the floor finish.
- I. Provide service fittings where required, complete with adapters and locking nipples suitable for use with the duct.

## **2.12 WIRE AND CABLE (600 VOLT)**

- A. Conductors: Conform to the requirements of the NEC.
  - 1. Feeder and Branch Circuit Conductors: Soft-drawn copper.
  - 2. Control Circuits: Soft-drawn copper.
  - 3. Conductor Sizes: Standard American Wire gauge sizes. Conductors No. 10 and smaller, solid copper; No. 8 and larger, stranded copper.
  - 4. Minimum AWG sizes unless otherwise indicated:
    - a. No. 12 for branch circuits.
    - b. No. 14 for control wire and fixture wire
    - c. No. 16 for low voltage circuit and indication wire.
  - 5. Wire shall be No. 10 AWG, type XHHW for luminaire feeder circuits from the lighting fixture elevation level for wood pole mounted lighting fixtures, or from the base of metal pole, or from adjacent handhole to luminaire.
  - 6. The feeder wires from the branch circuit cables to the luminaires shall have a pin and receptacle type connector in each line at the lighting fixture elevation level for wood pole mounted lighting fixtures, and at the base of a metal pole. The connector shall have a waterproof housing capable of being disconnected without damage. The connectors in the phase wires shall be the fused type and shall be fused at 15 amps. The neutral wire shall have an unfused connector.
  - 7. All other connections except for the connection at the base of metal pole shall be insulated by using a cast insulation of self-curing epoxy resin which is compatible with the wire insulation to form a moisture resistant joint, The resin shall be poured into rigid molds of dimensions suitable for the splice.
- B. Wire and Cable 600 volts and Below Installed Raceways: Single conductor, NEC type XHHW, conforming to requirements of NEMA WC 7, or THWN.
- C. Fixture Wire: Type AF single conductor, rated for 150°C conductor temperature, 300 volts.
- D. Color Coding of Conductors

1. Color code supply cables and branch circuit conductors throughout the secondary alternating current wiring system as follows:

Conductor	208/120 Volts	480/277 Volts
Ground	Green (or bare)	Green
Neutral	White	Grey
Line, A-Phase	Black	Brown
Line, B-Phase	Red	Orange
Line, C-Phase	Blue	Yellow

2. Color code single-conductor wires as follows:
  - a. 480/277 volt circuits, blue with yellow tracer.
  - b. 120/208 volt circuits, yellow with blue tracer.
3. Branch circuit phase conductors No. 10 and smaller and all neutral and equipment conductors: Solid color insulation or solid color coating.
4. Solid color coatings and tracers: A strongly adherent paint or dye not injurious to the insulation and which will not be obliterated by pulling into a conduit or raceway.
5. On-site coloring of ends of conductor may be permitted by the Engineer upon receipt of satisfactory evidence that the Contractor is unable to order color-coded wire and cable as specified. Provide certification from the cable manufacturer that the paint or dye proposed for field application is non-injurious to the insulation. Colored tape may be used to mark the ends of conductors in lieu of paint or dye.

E. Identification Tags

1. Provide waterproof identification tags of brass, aluminum, plastic, or pressure-sensitive moisture-resistant labels designed for fastening to cables, feeders, and power circuits in vaults, pull boxes, manholes, and switchboard rooms and at all terminations of cable or wire.
2. Stamp or print tags or labels to correspond with markings on the Contract Drawings or accepted Shop Drawings, or mark so that feeder, cable or conductor may be readily identified. Tags on conductors at switches, receptacles, motor control panels, wireways, and junction boxes shall bear the circuit number of the conductor as it appears in the circuit directory. Mark conductors in motor control panels with the terminal number.
3. If suspended type tags are provided, design tie tags with slip-free plastic cable lacing unit or design for attachment by nylon bundling straps.

F. Cable Supports and Fasteners: Design for use with channel inserts.

G. Conductor Bundling Straps

1. Formed from self-extinguishing nylon having a temperature range of minus 65°F to plus 250°F.
2. Equip each strap with a locking hub or head with a stainless steel locking barb on one end and a taper on the other end.
3. Make wire and cable ties for installation outdoors and in exposed locations of ultraviolet resistant nylon material.

H. Splice and Terminal Connectors

1. Design termination fittings for use with the cable furnished, NEMA Standard, and UL approved.

2. Termination and splice fittings for No. 10 and smaller conductors; Screw on, spring pressure-type copper connectors with nonflammable, self-extinguishing insulation of temperature rating equal to that of cable being connected. Terminals to provide a metal insulation grip on the conductor for strain relief.
3. Termination and splice fittings for No. 8 and larger conductors: Tool-applied compression connectors of material and design compatible with the conductors for which they are used.
4. Terminal connectors for conductors Size No. 4/0 and larger: Long-barrel, double compression type, and furnished with two bolting holes in the pad.

#### I. Insulating Material for Splices and Terminations

1. Of the type approved by the Engineer for the particular use, location and voltage, 3/4 inch nominal width.
2. Plastic electrical insulating tape for general use: Vinyl plastic with rubber-based pressure-sensitive adhesive. Pliable at temperature of minus 18°C to 105°C. When tested in accordance with ASTM D 3005, the tape shall have the following minimum properties:
  - a. Thickness: 7 mils.
  - b. Breaking Strength: 15 pounds per inch.
  - c. Elongation: 200%.
  - d. Dielectric Strength: 10,000 volts/mil
  - e. Insulation Resistance (Direct method of electrolytic corrosion): 1,000,000 megohms.
3. Rubber electrical insulating tape for protective overwrapping: Silicone rubber with a silicone pressure-sensitive adhesive. When tested in accordance with ASTM D1000, the tape shall have the following minimum properties:
  - a. Thickness: 15 mils.
  - b. Tensile Strength: 11 pounds per inch.
  - c. Elongation: 525%.
  - d. Dielectric Strength: 13,000 volts
  - e. Insulation Resistance (Indirect Method of Electrolytic corrosion): 1,000,000 megohms.
4. Arcproof Tape: Flexible, conformable organic fabric, coated one side with a flame-retardant flexible elastomer-self-extinguishing, with the following minimum properties:
  - a. Thickness, ASTM D1000: 55 mils.
  - b. Tensile strength, ASTM D1682: 50 pounds per inch.
  - c. Thermal conductivity, ASTM D1518: 0.478 btu/hour/square foot/degrees F.
  - d. Electrical Arc Resistance: Withstand 200 ampere arc for 40 seconds.
5. Mark each tape package to indicate shelf-life expiration date.
6. Glass Cloth Electrical Insulating Tape (for use with arcproof tape): Woven glass fabric; when tested in accordance with ASTM D1000, the tape shall have the following minimum properties:
  - a. Thickness: 7 mils
  - b. Breaking Strength: 170 pounds per inch.
  - c. Elongation: 5%.
  - d. Dielectric Breakdown: 2,500 volts.
  - e. Insulation Resistance (Indirect Method of Electrolytic Corrosion): 5,000 megohms.

## 2.13 WIRING DEVICES

- A. General. Wiring devices include switches, receptacles and special outlets installed in raceway or conduit boxes, complete with cover plates.

B. Switches

1. AC tumbler-toggle switches: Meeting minimum requirements of UL 20 and further requirements herein specified and of specification grade, heavy duty, of the type indicated.
2. Provide switches that operate in any position and are fully enclosed with entire body and cover of molded phenolic, urea or melamine. Do not use fiber, paper or similar insulating material for body or cover.
3. Equip switches with metal mounting yoke with plaster ears, insulated from the mechanism and fastened to the switch body by bolts, screws, rivets or other substantial means that meet test requirements.
4. Provide a green-colored equipment grounding screw on the yoke.
5. Provide the section of the yoke normally intended to bear on the surface outside the box with a minimum over-all dimension of 3/4 inch, measured at right angles to the longitudinal axis of the yoke.
6. Make switch contacts between silver or silver alloys.
7. Switches shall be back and side wired with terminals of screw or combination screw-clamp type.
8. Terminal Screws: No. 8 or larger, captive or terminal type.
9. Provide access holes for back wiring.
10. Wiring terminals capable of receiving and holding proper wire sizes as shown below:

Switch Rating	Wire Size, AWG No.
20 amperes	12 and 14
30 amperes	10

C. Wall switches: Tumbler type, totally enclosed, heavy duty, in accordance with NEMA WD 1.

- D. Switches for use on incandescent or fluorescent lighting circuits: Fully rated 20 amperes at 120 or 277 volts, as indicated. Actual connected lamp wattage not to exceed the following:

Switch Rating at 120-277 Volts	Maximum Wattage Allowed	
	120 Volts	277 Volts
20 amperes	1,400	3,000

- E. Switches controlling outlets other than lighting, such as motors less than 1/4 horsepower may be specification grade, flush type, AC - DC, T-rated 20 ampere, 125 volts. Switches controlling straight resistance loads may be snap switches as specified herein, of the proper rating up to 30 amperes at 120-277 volts.
- F. Provide ac 120-277 volt snap switches capable of withstanding tests as outlined in NEMA WD 1, Paragraphs WD 1-2.04, WD 1-2.05A, WD 1-2.05C, WD 1-2.05E2, WD 1-2.05F2, and WD 1-2.05G. If requested by the Engineer, submit satisfactory evidence that the types of switches proposed have satisfactorily withstood these tests.

## 2.14 RECEPTACLES AND PLUGS

- A. Configuration and requirements for connector and outlet receptacles; UL 498 and NEMA WD 1 for heavy duty general use type.

- B. Receptacles: Fire-resistant nonabsorptive, hotmolded phenolic composition or equal bodies and bases with metal plaster ears integral with supporting member.
- C. Type: Flush type, except where otherwise indicated.
  - 1. Wall receptacles; Single or duplex as shown on the Contract Drawings.
  - 2. Provide receptacles and plugs (caps) with light-colored terminal facilities for neutral connections, amber or brass colored for phase conductor connections, and green-colored hexagonal machine screws for the equipment grounding conductor or connections.
  - 3. All contracts of the receptacles, including the grounding contract: Double grip bronze type with spring steel backup clips so that both sides of each male prong of the plug will be in firm contact.
  - 4. Provide all receptacles with self-grounding clip or mounting strap screws.
  - 5. Ground fault circuit interrupter duplex receptacles shall be 120 volt, 60 Hz, 15 ampere with built-in test, reset buttons, and ground fault tripped indication. They shall interrupt the circuit within 1/30th of a second on a 5 milliamperes earth leakage current. They shall be designed for end of run installation or with provisions for feeding through to protect other outlets on the circuit. Maximum circuit capacity for the latter shall be 20 amperes. The receptacles shall be furnished with necessary wire connectors, clips, mounting scores and instruction.
- D. Clock Receptacles
  - 1. Receptacles for clocks are not required for clocks operating on less than fifty volts, and flush-mounted clocks (inserted type).
  - 2. Provide receptacles for clocks conforming to NEMA 5-15R, recessed so that male cap will be flush with the wall to permit the clock to cover the outlet.
  - 3. Provide plates, including finishes, as specified for cover plates, adapted to the recessed receptacles and with substantial hooks to support the clocks.
  - 4. Receptacles for surface-mounted clocks connected to the building 120-volt electrical system: As indicated.
  - 5. Where clock receptacles are shown on the Contract Drawings or specified, furnish the grounded type and provide with a ground jumper.

## **2.15 COVER PLATES**

- A. Provide cover plates for each switch, receptacle, and special purpose outlet.
- B. Use multi-gang plates for multi-gang boxes.
- C. Unless otherwise indicated, use cover plates conforming to FS W-P-455.
- D. Provide and install cover plates of brushed stainless steel in ancillary spaces, mechanical rooms, fan rooms, wire closets, AC switchboard rooms, traction substations, and all unfinished areas.
- E. In public areas provide cover plates fabricated of corrosion-resistant steel, 18% chromium, 8% nickel with baked porcelain enamel bronze finish.
- F. For special purpose outlets commercially produced using special material, configuration, and size, use plate of brushed stainless steel and of a design for the particular application.



- G. Where plates of material and finish herein specified are not available commercially for these special purpose outlets, plates commercially available and suitable for enameling to match adjacent surface will be acceptable.
- H. Use stainless steel cover plates of 0.040 thickness for flush devices.

## **2.16 DISCONNECTION DEVICES**

- A. Safety Switch Type Disconnecting Devices: Enclosed, conforming to UL Standards and the following:
  - 1. Motor Circuit Switches (600 Volts AC):
    - a. Furnish motor circuits with a separately mounted disconnect switch where required within sight of the motor.
    - b. Switch: HP rated, UL listed, quick make quick break, full cover interlock and indicator handle, conforming to FS W-S-865 for heavy duty switches.
    - c. Enclosure Type: As indicated.
    - d. Furnished handle mechanism with continuous engagement of the switch handle whether the door is open or closed, and is pad-lockable in the OFF and ON position.
  - 2. Heavy Duty Safety Switches (240 Volts AC):
    - a. Furnish heavy-duty safety switches having electrical characteristics, ratings, and modifications indicated.
    - b. Furnish switches with NEMA 12 General Purpose Enclosures, unless otherwise indicated, and with metal nameplates, front cover mounted, containing a permanent record of switch type, catalog number, and HP ratings.
    - c. Furnish handle with visible blades; reinforced fuse clips; nontearable, positive, quick make-quick break mechanism, and which is pad-lockable in the OFF and ON position.
    - d. Furnish switches meeting NEMA KS 1 requirements.
  - 3. Heavy Duty Safety Switches (600 Volts AC):
    - a. Furnish heavy-duty safety switches having electrical characteristics, ratings, and modifications shown on the Contract Drawings.
    - b. Furnish all switches with NEMA 12 General Purpose Enclosures, unless otherwise indicated, meeting NEMA KS 1 requirements.

## **PART 3 - EXECUTION**

### **3.1 GENERAL**

- A. The Contractor shall carefully follow the manufacturer's recommendation regarding the handling, bonding, coupling, and installation of the conduit and fittings as shown on the plans and specified herein. Thread protectors shall be installed at both ends of the conduit for shipment and handling. Couplings shall be packaged separately. Conduit shall be rigidly supported as required by methods and materials which will not cause injury to the conduit surface and which will not deform the conduit.
- B. Furnish anchor bolts and anchorage items as required, and field check to ensure proper alignment and location. Provide templates, layout drawings, and supervision at the job site to ensure correct placing of anchorage items in concrete. Check embedded items for correctness of location and detail before concrete is placed.

- C. Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts and angles as required to set and connect rigidly the work.
- D. Control erection tolerance requirements to not impair the strength, safety, serviceability, or appearance of the installations, as approved by the Engineer. Determine exact location of conduit. Route all conduit parallel to building lines.
- E. The trade size, type and general routing and location of conduits, raceways, and boxes shall be as indicated.
- F. Install exposed conduit so as to avoid conflicts with other work. Install horizontal raceway close to the ceiling or ceiling beams, and above water or other piping whenever possible.
- G. Install individual conductors in conduits, raceways, cable trays, ducts, and trenches and multiple-conductor sheathed cables as shown on the Contract Drawings to complete the wiring systems.
- H. Install switches, receptacles, special purpose outlets, and cover plates complete in a neat manner in accordance with the NEC and local electrical codes.

### **3.2 CONDUIT AND FITTINGS**

#### **A. Electrical Conduit**

1. The trench for a single conduit line shall be excavated to a width of 18 inches to a depth of not less than 36 inches below the proposed grade of the finished pavement as shown on the Contract plans. If the condition of the bottom of the excavated trench is wet, clayey or spongy, or otherwise unsatisfactory, the Engineer may require that the bottom of the trench be excavated deeper and the space filled with clean gravel to form a firm bearing for tie conduit. The gravel shall be firmly compacted in layers not over six inches in depth. The grade of the finished trench shall be parallel to the proposed pitch of the conduit or duct. After the trench has been excavated to the proper width and depth as specified above, a gravel foundation six inches in depth shall be constructed on the bottom of the trench to provide a proper cushion for the conduit. This cushion of gravel shall be thoroughly tamped. Gravel fill shall be made around the sides of the conduit and over it for a depth of three inches and thoroughly tamped.
2. Make all conduit bends in accordance with the NEC, with not more than 3 bends per run. Where more than 3 bends are required in a particular run, install pull boxes as required to facilitate pulling conductors.
3. Unless otherwise indicated, terminate metallic conduit installed for future extension with flush couplings set to finished floor level.
4. Provide metallic numbering tags indicating the conduit number on the end of conduit. Identify train control and communication conduit as indicated.
5. Properly support conduit to be embedded to maintain correct location and spacing during concreting operations. If necessary, provide suitable metal supports for this purpose.
6. Install conduit so that any moisture collecting in the conduit will be drained to the nearest outlet or pull box.
7. Whenever exposed or buried conduit passes through an expansion or contraction joint in the structure, install the conduit at right angles to the joint, and provide an approved conduit expansion joint at the joint. Paint the conduit with an approved bituminous compound for one foot on each side of the expansion couplings.
8. Provide expansion joints in conduit runs where required to compensate for thermal expansion.

9. Rod and swab embedded conduit after installation to remove foreign matter, which may have worked in at the joints. If obstructions are encountered which cannot be removed, or if any conditions exist which may result in damage to wires and cables pulled through the conduit, install new conduit at no additional expense to the Authority.
10. After the conduit has been rodded and swabbed, repack boxes and protect conduit ends to prevent any foreign material from entering the conduit.
11. Where metallic conduit is exposed to different temperatures, seal the conduit to prevent condensation and passage of air from one area to the other.
12. Use only conduits that are electrically and mechanically continuous and connect to the structure ground system. Secure continuous ground by bonding where required.
13. Apply conductive antisieze compound to the threads of threaded rigid conduit joints. Do not use compounds containing lead. Terminate the conduit in appropriate boxes at all motors, switches, outlets, and junction points.
14. When field cutting of conduit is required, thread and ream the conduit to remove any rough edges. Where a conduit enters a box or other fitting, provide a bushing to protect the wire from abrasion. Provide insulation type bushings and double locknuts on ends of rigid conduits terminating at steel boxes, panelboards, cabinets, motor starting equipment, and similar enclosures.
15. Support individual horizontal conduits not larger than 1-1/2 inches diameter by means of one-hole pipe straps with back spacers or individual pipe hangers.
16. Space conduits installed against concrete surfaces away from the surface by clamp backs or other approved means.
17. Support individual horizontal conduits larger than 1-1/2 inches diameter by individual pipe hangers.
18. In dry locations, spring steel fasteners, clips, or clamps specifically designed for supporting exposed single conduits may be used in lieu of pipe straps or pipe hangers.
19. Hanger rods used in connection with spring steel fasteners, clips, and clamps shall be either 1/4-inch diameter galvanized steel rods or, if concealed above a suspended ceiling, galvanized perforated steel strapping. Do not use wire for support of conduit.
20. Support parallel conduits at the same elevation on multiple conduit hangers or channel inserts. Secure each conduit to the pipe hanger or channel insert member by a U-bolt, one-hole strap, or other specially designed and approved fastener suitable for use with the pipe hangers or channel inserts.
21. Space supports not over 10 feet on centers for vertical conduits spanning open areas. Securely anchor conduit at each end and run so as not to interfere with the installation and operation of equipment at the location.
22. Support conduits and raceways above suspended ceilings from either the floor construction above or from the main ceiling support members, using the applicable method specified herein.
23. Install liquid-tight flexible metal conduit so that liquids tend to run off the surface and not drain toward fittings. Provide sufficient slack to reduce the effects of vibration. Running threads are not acceptable. Where necessary for connecting conduits, use right and left hand couplings.

#### B. Non-Metallic Electrical Conduit

1. Non-metallic electrical conduit includes polyvinyl chloride (PVC) and asbestos cement conduit.
2. Cap or plug the ends of embedded conduit to prevent concrete and other materials from obstructing the conduit.
3. Sandpaper joints in PVC conduit to remove all burrs, clean and dry the joints, and brush with a solvent cement acceptable to the manufacturer before installing.

4. Properly support conduits to maintain the correct location and spacing during concreting operations and, if necessary, provide suitable plastic supports and spacers for this purpose.
5. Wherever buried non-metallic conduit passes through an expansion or contraction joint, or where required to compensate for thermal expansion and contraction, provide a conduit expansion joint. Install the conduit to cross the joint at right angles. In areas of floating slabs, install horizontal runs of conduit beneath the floating slab. Conduit shall pass through the floating slab only where required to terminate in a vertical direction as shown on the Contract Drawings.

C. Pull Wires

1. Use nylon pull wires of tensile strength not less than 240 pounds in each conduit and duct, leave pull wires in ducts and conduit after cleaning.
2. No splices in pull wire will be allowed.
3. Leave ample slack length at each end of pull wire.

D. Filling of Openings. Wherever slots, sleeves, or other openings are provided in floors or walls for the passage of raceways, including bus ducts, fill such openings as follows:

1. Use fire-resistive filling material for openings similar to the material of the floor, wall or ceiling being penetrated, and finish to prevent passage of water, smoke, and fumes.
2. Where conduits passing through openings are exposed in finished rooms, use filling material that matches, and is flush with, the adjoining finished floor, ceiling or wall.

### **3.3 INSERTS**

A. Channel Inserts. Install embedded channel inserts with the slotted face flush with the finished concrete surface.

B. Spot Inserts

1. Install with the insert face flush with the finished concrete surface, firmly embedded, with no evidence of movement.
2. Test selected inserts, as required by the Engineer, by suspension of 800 pounds of weight from the insert. If there is evidence of failure, replace the inserts in a manner satisfactory to the Engineer.

### **3.4 SURFACE METAL RACEWAYS**

- A. Securely ground surface metal raceways to outlet boxes or to backplates and fixtures by means of bolts, screws or other approved means and as specified in Section 16450 - GROUNDING.
- B. Install surface metal raceways where indicated, in accordance with the NEC. Use fittings and accessories designed for the raceway.

### **3.5 OUTLET, JUNCTION AND PULL BOXES**

A. Outlet Boxes

1. Unless otherwise indicated, flush mount outlet boxes with the front edges of the boxes or plaster covers attached thereto flush with the finished wall or ceiling.

2. Mount boxes so that the long axis of the devices will be vertical, unless otherwise indicated.
3. Locate conduit boxes and conduit box knockouts so as not to interfere with the reinforcing steel.
4. Unless otherwise specified, provide boxes in plastered walls and ceilings with plaster covers. Do not install these covers until the finish plaster line is determined for the particular location.
5. The mounting height indicated for a wall-mounted outlet box shall be construed to mean the height from the finished floor to the horizontal centerline of the cover plate.
6. Mount outlet boxes for switches and receptacles located on columns and pilasters so as not to interfere with installation of partitions.
7. Install boxes located near doors on the lock sides, even where the symbols appear on the hinge sides on the Contract Drawings, unless other locations are approved by the Engineer.

**B. Junction and Pull Boxes**

1. Install so that covers are readily accessible after completion of the installation.
2. Do not install boxes above suspended ceilings, except where the ceiling is of the removable type or where definite provisions are made for access to each box.

**C. Boxes Set in Concrete**

1. Adequately support boxes to prevent movement during placement of concrete.
2. Unused nailing holes or other holes in the side or bottom of the boxes will not be permitted.
3. After installation, clean boxes placed in concrete.

### **3.6 CABLE TRAYS**

- A. Install as shown on the Contract Drawings and in accordance with NEC Article 318 using approved fittings and adequately supporting the complete system.
- B. Provide anti-sway brackets on all horizontal tray assemblies where necessary.
- C. Connect each isolated cable tray system or the entire tray system to the building equipment grounding system with a green insulated conductor in accordance with the NEC.
- D. Base size determination on the largest power conductor in the rack.
  1. Minimum size: No. 6
  2. Maximum size: 4/0 copper

### **3.7 UNDERFLOOR DUCTS AND FITTINGS**

- A. Install as shown on the Contract Drawings.
- B. Accurately align and level the ducts with the top of inserts 1/8 inch below the finished concrete floor.
- C. Hold ducts in place during pouring of concrete by use of duct support fitting designed for the duct used, spaced at five-foot intervals. Carefully level all boxes, with the tops flush with the finish floor.

- D. Install appropriate insert markers in the last insert at all dead ends, on each side of partitions, and first insert adjacent to junction box to indicate high and low voltage services.
- E. Seal duct installation watertight with an approved sealing compound.

### **3.8 WIRING**

#### **A. General**

1. Furnish wires and cables to the site in unbroken standard coils or reels, to which shall be attached a tag bearing the manufacturer's name, trade name of the wire, and the UL label for 600 volt wire and cable.
2. Provide all wiring complete as indicated. Provide ample slack wire for motor loops, service connections and extensions. In outlet or junction boxes provided for installation of equipment by others, tape ends of wires and install blank covers.
3. Do not bend cables during installation, either permanently or temporarily, to radii less than 12 times the outer diameters, except where conditions make the specified radius impracticable, and shorter radii are permitted by the NEC and NEMA Standard WC 7, Appendix N.
4. Neatly and securely bundle cable conductors located in branch circuit panelboards, cabinets, control boards, switchboards and motor control centers and pull boxes. Use nylon bundling straps.
5. Sufficient cable and wire slack shall be allowed in equipment enclosures to provide for neat racking and movement due to thermal expansion and contraction.

#### **B. Wire Pulling**

1. Install wire and cable in conduit as indicated. Do not pull wiring into any conduit until conduits and outlets have been thoroughly cleaned and swabbed to remove water and debris. Do not use block or tackle or other mechanical means in pulling conductors smaller than No. 2 AWG in raceways.
2. Provide suitable installation equipment to prevent cutting and abrasion of conduits and wire during the pulling of feeders. Use lubricant and installation procedure as recommended by the cable manufacturer, and as approved by the Engineer.
3. Use masking or other means to prevent obliteration of cable identifications when solid color coating or colored tracers are used.
4. Pull together all cables to be installed in a single conduit.
5. All conductors and grounding wire shall be drawn into ducts or conduits without damage to covering, sheath, insulation, or wires. This wiring shall not be done until all work which may damage the wires has been completed. In pulling, all wires shall be drawn freely into conduits without kinks or bends, twisting or lapping. In general, all conductors in each conduit run shall be pulled at the same time, fed from free running reels. Powdered soapstone, talcum, or other approved lubricant may be used to assist in placing wire and cable in conduits.

#### **C. Cable Supports. Install cable supports for vertical feeders in accordance with the NEC.**

#### **D. Splices and Terminations**

1. Make wire and cable splices only in outlet, junction or pull boxes, or in equipment cabinets. Splices in conduit or raceway will not be permitted. Make splices by means of compression type connectors, and cover with tape to an insulation level equal to that of the cable.
2. Use positive type connector installation tools as recommended by the manufacturer.

3. Mechanical hand tools, with dies for each conductor size, recommended by the manufacturer, may be used on conductor sizes through No. 4/0.
4. For conductor sizes larger than No. 4/0, use hydraulic tools with hexagonal or circumferential installing dies for each conductor size, as recommended by the manufacturer.
5. For inspection purposes, clearly mark die numbers on the installed connectors.
6. Before installation, apply anti-corrosion electrical joint compound to conductors and terminal bolting pads.

E. Testing

1. The entire electrical wiring system shall be tested for continuity, grounds, resistance to ground, insulation resistance, shorts, and opens. This shall be done by means of a megohm-meter test. After installation of the wiring system complete with the required splices, the lamp ballast primary shall be disconnected, and each circuit shall be tested with a 1,000 volt megger. Tests on each circuit shall be between an insulated conductor and an uninsulated conductor, the Contractor shall locate the point or points at fault and make proper corrections and then demonstrate by another test the elimination of such faults. These tests shall be performed in the presence of the Engineer. The test results shall be submitted to the Engineer for further review and approval. If any results are questionable or inconsistent, the Contractor shall repeat the tests and make any necessary corrections at the request of the Engineer. No wiring system will be accepted until these tests are satisfactorily performed and approved. The Contractor shall furnish the Engineer with a report of the megohm-meter readings for a permanent Project record. All tests and any necessary repairs or replacements which are indicated by them to produce a fault-free system will be performed at the Contractor's expense.

### 3.9 WIRING DEVICES

- A. Locate switches four feet above finished floor, except as otherwise indicated.
- B. Attach receptacles rigidly to outlet box by means of two screws.
- C. Wire duplex receptacles, where so indicated, so that one unit of the duplex may be controlled by a wall switch and the other unit remain continuously energized.
- D. For exterior locations, mount receptacles in watertight cast type outlet boxes with threaded hubs or bosses and equipped with gasketed cover and captive cap of the screw or twist type.
- E. Provide equipment permanently connected to exterior receptacles, or in areas subject to spray or hose cleaning, with watertight male plugs to suit. Such receptacles shall be of the ground fault circuit interrupter type, as specified herein.
- F. Furnish one matching plug with each receptacle, as indicated, installed in the work.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 GENERAL**

- A. No separate measurement or payment will be made for work of this Section, but all costs in connection therewith shall be included in the Lump Sum prices. All preparation and incidental work necessary to accomplish the installation will be considered incidental to the Lump Sum prices.

**END OF SECTION**



## **SECTION 16195**

### **ELECTRICAL IDENTIFICATION**

#### **PART I - GENERAL**

##### **1.1 DESCRIPTION OF WORK**

- A.** Work Included: This Section specifies the furnishing and installing of nameplates and labels, wire and cable markers, and conduit markers. Engraved nameplates shall be designed, furnished and installed for every major piece of electrical equipment shown on the single-line diagrams. The single-line diagrams are shown on the Contract drawings.
- B.** Related requirements are included in, but not limited to, the following Sections.
  - 1. Section 09900: PAINTING
  - 2. Section 16050: BASIC MATERIALS AND METHODS FOR ELECTRICAL WORK

##### **1.2 REFERENCES**

- A.** National Fire Protection Association (NFPA)
  - 1. NFPA No. 70 - National Electrical Code

##### **1.3 SUBMITTALS**

- A.** Submit in accordance with Section 01300, except as modified herein.
- B.** Product Data/Catalog Cuts
  - 1. Nameplates and labels.
  - 2. Wire and cable markers.
  - 3. Conduit markers.
- C.** Certificates of Compliance
  - 1. Nameplates and labels.
  - 2. Wire and cable markers.
  - 3. Conduit markers.
- D.** Manufacturer's Instructions
  - 1. Delivery, handling, transportation, storage and protection.
  - 2. Surface preparation, and application/installation of products.
  - 3. Application conditions and limitations of use.
- E.** Engraved nameplate schedule shall be submitted for review and approval by the Engineer.
- F.** Submittals required for painting work shall be as specified in Section 09900.

##### **1.4 DELIVERY, HANDLING, TRANSPORTATION, STORAGE AND PROTECTION**

Delivery, handling, transportation, storage and protection shall be in accordance with the manufacturer's instructions, unless otherwise required by Division 1.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL REQUIREMENTS**

- A.** Conform to requirements of NFPA No. 70.
- B.** Provide products listed and classified by Underwriters Laboratories, or a testing firm acceptable to authorities having jurisdiction as suitable for purpose specified and indicated.
  - 1. The Contractor shall submit certificates of compliance for products provided.
  - 2. The Contractor shall provide the manufacturer's instructions indicating application conditions and limitations of use stipulated by the product testing agency.

### **2.2 NAMEPLATES AND LABELS FOR EQUIPMENT**

- A.** Nameplates and Labels
  - 1. Engraved three-layer laminated plastic, black letters on white background.
- B.** Locations
  - 1. Electrical equipment including, but not limited to, each electrical distribution enclosure and control equipment enclosure, communication cabinets, transfer switches and panels.
- C.** Letter Sizes:
  - 1. Use 1/4-inch letters for identifying individual equipment and loads.
  - 2. Use 1/4-inch letters for identifying grouped equipment and loads.
  - 3. Use 1/8-inch letters for identifying voltage, phase, and neutral.

### **2.3 WIRE MARKERS**

- A.** Wire markers shall be manufactured by Panduit, Ideal, 3M, or approved equal.
  - 1. Description: Cloth tape or tubing type wire markers.
  - 2. Locations: Each conductor at panelboard, gutters, pull boxes, outlet and junction boxes and each load connection.
- B.** Legend
  - 1. Power and lighting circuits: Branch circuit or feeder number indicated on the Drawings.
    - a. Control circuits: Control wire number indicated on schematic and interconnection diagrams on the Drawings.
  - 2. Power supervisory control and data acquisition (SCADA) system circuits:
    - a. Circuits shown on the riser diagrams or schematic diagrams. The riser diagrams and schematic diagrams are shown on the Drawings.

### **2.4 CONDUIT MARKERS**

- A.** Conduit markers shall be manufactured by Banded Labeling System, Brady USA, Inc., Panduit, or approved equal.
- B.** Location: Furnish markers for each conduit longer than 6 feet.

**C. Spacing**

1. Spacing shall be 20 feet on center, unless otherwise specified.

**D. Color:**

<u>System Name</u>	<u>Color</u>
1. 240 volt system	Per NEC
2. Telephone system	Gray
3. Management information system	Purple
4. Passenger assistance system	Green
5. Closed circuit television system	Black
6. Power SCADA	Pink

**E. Legend:**

<u>System Name</u>	<u>Legend</u>
1. 240 volt system	240 V
2. Telephone system	TS
3. Management information system	MIS -
4. Passenger assistance system	PNRA
5. Closed circuit television system	CCTV
6. Power SCADA	PSCADA

## **2.5 PAINTED CONDUIT IDENTIFICATION**

- A.** Conduit shall be painted for identification purposes. Paint system Identification Number shall be as specified Section 09900 - PAINTING

- B.** Paint colored band on each conduit longer than 6 feet.

- C.** Paint bands, 3 inches wide, 20 feet on center, unless otherwise specified.

**D. Color**

<u>System Name</u>	<u>Color</u>
1. 240 volt system	Per NEC
2. Telephone system	Gray
3. Management information system	Purple
4. Passenger assistance system	Green
5. Closed circuit television system	Black
6. Power SCADA	Pink

## **2.6 UNDERGROUND WARNING TAPE**

- A.** Underground warning tape shall be manufactured by Panduit, Ideal, Seton, or approved equal.
- B.** Description: Underground warning tape shall be 6 inch wide plastic tape, colored yellow with suitable warning legend describing: CAUTION - BURIED ELECTRICAL LINES BELOW.

## **PART 3 - EXECUTION**

### **3.1 PREPARATION**

MassDOT Project No. 604428  
2014

ELECTRICAL IDENTIFICATION  
16195-3

Degrease and clean surfaces to receive nameplates, labels and markers, in accordance with the manufacturer's instructions.

### **3.2 APPLICATION INSTALLATION**

**A.** Application/installation of products shall be in accordance with the manufacturer's instructions.

**B.** Nameplates and Labels

1. Install nameplates and labels parallel to equipment lines.
2. Secure nameplate to equipment front using screws.
3. Secure nameplate to inside surface of door on panelboard that is recessed in finished locations.

**C.** Conduit Identification by Markers

1. Identify conduit using conduit markers.
  - a. Apply conduit markers parallel to conduit runs.

**D.** Conduit Identification by Painting

1. Identify conduit, using paint. Paint shall be field applied.
  - a. Painting, including surface preparation, shall be in accordance with Section 09900 - PAINTING

**E.** Identify underground conduits using underground warning tape. Install one tape per trench at 12 inches below finished grade.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 GENERAL**

No separate measurement or payment will be made for work required under this Section. All costs in connection therewith shall be considered incidental to the item or items of work to which they pertain.

## **END OF SECTION**

**SECTION 16325  
CONDUIT SYSTEM**

**PART 1 - GENERAL**

**1.01 DESCRIPTION**

- A. This Section specifies furnishing and installing various types of conduits and duct bank systems to include conduit, concrete encased duct banks, handholes and associated appurtenances as specified herein and as shown on the Contract Drawings.

**1.02 QUALITY ASSURANCE**

- A. Workmanship shall conform with the best modern practices for a rugged, long-lived, safe installation required for a public transportation system. Materials to be installed shall be new and of the highest commercial grade as specified.

**1.03 SUBMITTALS**

- A. The Contractor shall submit the following for approval:
  - 1. Catalog cuts and descriptive literature for all materials as specified herein and as shown on the Contract Drawings.
- B. "As-Built" drawings, prior to Authority acceptance.

**PART 2 - PRODUCTS**

**2.01 ELECTRICAL AND TELEPHONE MANHOLES AND HANDHOLES**

- A. Manhole and Handhole structures shall be cast-in-place concrete conforming to the requirements of Section 03300 or precast concrete conforming to the requirements of Section 03410, at the option of the Contractor.
- B. Handholes shall be furnished complete with conduit sleeves, reinforcing steel, frames and covers, drain sumps and other associated items as specified herein and as shown on the Contract Drawings.
- C. Precast units (if used) shall be the product of a manufacturer regularly engaged in the manufacture of precast concrete products.
  - 1. Concrete for precast work shall have an ultimate 28-day compressive strength of not less than 4,000 pounds per square inch. Handholes may be precast monolithically and placed as a unit; or, they may be of assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. All structures shall be identified with the manufacturer's name embedded in, or otherwise permanently attached to, an interior wall face.

2. Design for assembled units: Precast structures shall be designed in accordance with ACI-318 and shall be based on the following properties:
  - a. Angle of internal friction equals 30 degrees. Unit weight of soil equals 110 pounds per square foot.
  - b. Lateral at rest earth-pressure coefficient equals 0.50 above water-table, equals 0.90 below water-table.
- D. Sump wells shall be provided in all handholes and shall be 12 inches square and 4 inches deep.
- E. Handhole sections shall conform to AASHTO M199 specification, except as modified herein.
- F. Handhole frames and covers shall be heavy-duty cast iron, suitable for H-20 wheel loading. Covers shall be vented for atmospheric testing as shown on the Contract Drawings. Each cover shall be casted with the logos "MBTA COMMUNICATIONS", "MBTA ELECTRICAL" and or as indicated on the Contract Drawings or as directed by the Engineer.
- G. Handhole frames, covers and ferrous hardware shall be hot-dipped galvanized after fabrication in conformance with ASTM Specification A123.

## **2.02 CONDUIT**

- A. General. Conduits and fittings shall be free, within commercial tolerances, of objectionable lines, bubbles, chipped ends, and other manufacturing defects, that would impair the service of the conduit. The bore of the conduit shall be straight and circular in cross section with smooth interior surfaces free from obstructions and rough and flaky areas. The conduit and fittings shall be free from all substances that may injuriously affect any wire or cable covering. The numbers and sizes of the conduits shall be as shown on the Contract Drawings. At locations where conduits are required governed by these Specifications and as shown on the Contract Drawings, the various types of conduits to be furnished are specified below.
- B. Rigid Metal Conduit. Rigid metal conduit shall be used at locations as specified within these Specifications and as shown on the Contract Drawings. The types of rigid metal conduit to be used for the various applications shall be as follows:
  1. Galvanized Rigid Steel (RGS) Conduit
    - a. Steel conduit and fittings shall be made of the best grade standard weight steel pipe protected inside and outside by a coat of hot-dip galvanizing. Where sweeps are used, they shall be the long radius type. Steel conduits shall be protected in shipping and handling by approved thread protectors.
    - b. Galvanize Touch-Up. Where galvanizing is removed by welding or other assembly procedures, touch-up abraded areas with two coats of zinc-rich chromate paint designed for repair of galvanizing in accordance with ASTM Specification A780.

C. PVC Coated Rigid Galvanized Steel Electrical Conduit

NEMA Standard No. RN1, Coating Type A-40. Steel conduit and shall be made of the best grade standard weight steel pipe protected inside and outside by a coat of hot-dip galvanizing with overall outer PVC coating.

Thread protectors installed on both ends of conduit for shipment and handling, couplings packaged separately.

D. PVC Schedule 80 Electrical Conduit

- a. Heavy wall, high impact strength, ridged strength PVC conduit shall be installed as indicated on the Contract Drawings.

## **2.03 CONCRETE ENCASED DUCT BANKS**

A. Concrete and Formwork

1. All concrete used in duct banks shall conform to the requirements of Section 03300 for ASTM C150, Type II portland cement concrete. All formwork used shall conform to the requirements of Section 03100 and Section 901 of the MassDOT Highway Division Standard Specifications for Highways and Bridges.

B. Concrete Reinforcement

1. Concrete reinforcement shall be as indicated on the Contract Drawings conforming to the requirements of Section 03200 Section, and 901 of the MassDOT Highway Division Standard Specifications for Highways and Bridges.

## **2.04 DUCT SPACERS**

A. Duct spacers shall be furnished for concrete encased duct banks and direct burial conduit application.

B. Duct spacers shall be made of high impact plastic, designed to maintain a 2-inch minimum spacing between conduits. Spacers shall be capable of interlocking any combination of duct sizes, horizontally and vertically, and all types of duct (FRE, Galvanized Steel).

## **2.05 PULL LINE**

A. Pull line shall be 3/16" (minimum) in diameter with a tensile strength of 720 pounds (minimum). Pull line shall be of a polypro material, highly visible bright yellow and weather resistant.

## **2.06 BACKFILL**

- A. Backfill material shall conform to the requirements of Section 02300 and Section 801 of the MassDOT Highway Division Standard Specifications for Highways and Bridges.

## **2.07 CONDUIT MARKER TAPE**

- A. Furnish polyethylene conduit marker tape (non-adhesive) over the conduit system. Tape shall be bright yellow, six inches wide and continuously coded in black lettering with the following legend:

CAUTION                  CAUTION                  CAUTION      CAUTION  
SIGNAL   AND   ELECTRICAL                  CABLE   BURIED   BELOW

## **2.08 GROUNDING**

- A. Grounding material for electrical manholes and handholes shall conform to the requirements of Section 16450.

# **PART 3 - EXECUTION**

## **3.01 EXCAVATION AND BACKFILLING**

- A. Excavation and backfilling requirements shall be performed in accordance with Section 02200, and Section 801 of the MassDOT Highway Division Standard Specifications for Highways and Bridges.

## **3.02 ELECTRICAL AND TELEPHONE HANDHOLES**

- A. Handholes shall be installed on eight inches of gravel (min.) or special borrow approximately in the locations as shown on the Contract Drawings. The exact locations shall be determined after careful consideration has been given to the location of existing and proposed utilities, drainage systems and grades.

## **3.03 CONCRETE ENCASED DUCT BANKS**

- A. General
  - 1. Conduits shall be wiped clean thoroughly before being installed.
  - 2. Couplings, adapters and fittings for the ducts shall be installed in accordance with the manufacturer's recommendation.
- B. Each single conduit of the duct bank structure shall be completely encased in concrete as indicated on the Contract Drawings. The thickness of concrete encasement indicated is the minimum thickness, and may be increased to fit the actual shape of the trench. Duct spacers shall be used to support the conduits both vertically and horizontally. Duct spacers shall be placed at 5 foot intervals (maximum). Ducts shall be anchored securely to prevent concrete encasement from deforming.



- C. The concrete structure and conduits shall be installed with a minimum continuous slope of six inches per one hundred feet. Duct banks shall slope downward toward the handhole; from one handhole to the next or in both directions from a high point between the handholes.
- D. Changes in direction of conduit runs exceeding a total of ten degrees, either vertical or horizontal, shall be accomplished by long radius bends which have a minimum radius of curvature of 25 feet, except that manufactured bends may be used at the ends of the run. The long sweep bends may be made up on one or more curved or straight sections or combinations thereof. Manufactured sweeps shall have a minimum radius of 36 inches, or 48 inches as required by the conduit size.
- E. During construction and after the duct bank is completed, the ends of the conduits shall be plugged to prevent water from washing mud or other obstructing material into the conduits. Particular care shall be taken to keep the ducts clear of concrete, dirt and any other substance during the course of construction. Where it is necessary to cut a tapered end on a piece of conduit at the site, the cut shall be made with a tool or lathe that is designed to cut a taper to match the taper of the particular conduit that is being used.
- F. After the duct bank structure has been completed, a standard flexible mandrel, not less than 12 inches long and approximately 1/4 inch less in diameter than the inside diameter of the conduit, shall be pulled through each conduit. After this, a brush with stiff bristles shall be pulled through each conduit to make certain that no particles of earth, sand or gravel have been left in the line. An approved pull wire shall be installed in each conduit after brushing and the ends shall be plugged in a manner that will positively prevent entry of foreign objects. Pneumatic rodding may be used to draw in the pull line.

### **3.04 DIRECT BURIED CONDUITS**

- A. Direct buried conduits shall be installed as described for concrete encased duct banks, with the exception of the concrete encasement.
- B. Where conduit runs parallel the tracks, conduits shall be buried a minimum of 30 inches below finished grade or ballast.

### **3.05 CONDUIT MARKER TAPE**

- A. Conduit marker tape shall be installed over each duct bank or direct buried conduit run approximately 12 inches below finished grade for the full length of each run.

### **3.06 CABLES**

- A. Cables to be installed within the new conduits shall be installed in accordance with Section 16050.

### **3.07 CLEANUP AND DISPOSAL**

- A. Immediately upon completion of all work as required by this Section or any segments thereof, and as directed by the Engineer, remove and dispose of all debris and surplus excavated material away from the site.

#### **PART 4 - MEASUREMENT AND PAYMENT**

##### **4.01 GENERAL**

- A. The 3-inch PVC conduit supplying power for the busway lighting and the BRT station power and lighting systems shall be paid for under the contract unit price for Item No. 804.3 – 3 Inch Electrical Conduit Type NM – Plastic (UL).
- B. Separate measurement and payment will not be made for all other work required under this Section, complete in place, but all costs in connection therefore, will be included in the Contract Lump Sum Prices for the items of work to which it pertains.

**END OF SECTION**

**SECTION 16410**  
**SURGE PROTECTION DEVICES**  
**PART 1 - GENERAL**

**1.01 DESCRIPTION**

This specification specifies providing Surge Protection Devices (SPD) integral to the electrical distribution system equipment as indicated on the Contract Drawings. The distribution system includes 120/208V, 120/240V, 480Y/277 panelboards.

The components shall provide protection for electrical and electronic devices against the damaging effects of surges, transients and electrical line noise.

Provide SPD devices UL listed for lightning protection system applications.

**1.02 RELATED SECTIONS**

Division 16 - Electrical

**1.03 REFERENCES**

- A. Underwriters Laboratory (UL)
  - 1. ANSI/UL 1449 Third Addition – Standard For Safety – Surge Suppression Devices
  - 2. UL 1283 – Standard for Safety – Electromagnetic Interference Filters
- B. National Electric Code and all applicable state and local codes.
- C. American National Standard Institute (ANSI)/Institute of Electrical and Electronic Engineers (IEEE):
  - ANSI/IEEE C62.41 - IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits
  - ANSI/IEEE C62.45 - IEEE Recommended Practice on Surge Testing for Equipment Connected to Low Voltage (1000 V and less) AC Power Circuits.
  - National Electrical Manufacturers Association (NEMA):
    - NEMA 250 – Enclosures for Electrical Equipment (1000 volts maximum)
    - NEMA LS 1 – Low Voltage Surge Protection Devices

**1.04 SUBMITTALS**

- A. Submit descriptive literature and manufacturer specification sheets for surge protection devices as specified herein.
  - 1. Shop drawings, manufacturer's product data, and component ratings in accordance with this section and the requirements of Section 16050.

2. Provide verification that the SPD complies with the required ANSI/UL 1449 3<sup>rd</sup> edition listing by UL.
3. SPD type, model number, system voltage, phases, modes of protection, Maximum Continuous Operating Voltage (MCOV) Voltage Protection Rating (VPR), Short Circuit Current Rating (SCCR), and Nominal Discharge Current (In).
4. Outline drawings and internal wiring diagrams, including ratings of overcurrent circuit protection included with or provided for the unit.
5. Where separate Surge protection Devices are required by the Contract Drawings, provide manufacturer's standard installation requirements.
6. Factory test data.
7. Operating and Maintenance Instruction Manuals:
  - a. Furnish:
    - (1) Operating instruction manuals outlining step-by-step procedures for system startup and operation and in accordance with Section 01300.
    - (2) Manufacturer's name, model number, service manual parts list.
    - (3) Brief description of equipment and basic operating features.
    - (4) Maintenance instruction manuals outlining maintenance procedures.
    - (5) Troubleshooting guide listing possible breakdown and repairs.
    - (6) Simplified connection wiring diagrams for each circuit.

## **1.05 QUALITY ASSURANCE**

- A. SPD units and all components shall be designed manufactured and tested in accordance with the latest applicable UL Standard (ANSI/UL 1449 3<sup>rd</sup> Edition).

## **PART 2 - PRODUCTS**

### **2.01 ACCEPTABLE MANUFACTURERS:**

Surge Protection Devices.

1. Eaton-Cutler Hammer
2. General Electric
3. Siemens
4. Or equal.

## GENERAL:

### Electrical Requirements:

5. Unit Operating Voltage – Refer to drawings for operating voltage and unit configuration.
6. Maximum Continuous Operating Voltage (MCOV) – The MCOV shall not be less than 125% of the nominal system operating voltage.
7. Short Circuit Current Rating (SCCR) – The minimum SCCR of the SPD types 1 and 2 shall be 100 KA.
8. The suppression system shall incorporate thermally protected metal-oxide varistors (MOVs) as the core surge suppression component for the service entrance and all other distribution levels. The system shall not utilize silicon avalanche diodes, selenium cells, air gaps, or other components that may crowbar the system voltage leading to system upset or create any environmental hazards.
9. Protection Modes – The SPD must protect all modes of the electrical system being utilized. The required protection modes are indicated by bullets in the following table:

	Protection Modes			
Configuration	L-N	L-G	L-L	N-G
Wye	•	•	•	•
Delta	N/A	•	•	N/A
Single Split Phase	•	•	•	•
High Leg Delta	•	•	•	•

10. Nominal Discharge Current ( $I_n$ ) – All SPDs applied to the distribution system shall have a 20kA  $I_n$  rating regardless of their SPD Type (includes Types 1 and 2) or operating voltage. SPDs having an  $I_n$  less than 20kA shall be rejected.
11. ANSI/UL 1449 3rd Edition Voltage Protection Rating (VPR) – The maximum ANSI/UL 1449 3rd Edition VPR for the device shall not exceed the following:

MODES	208Y/120	240/120	480Y/277
L-N; L-G; N-G	4600V	4600V	1100V
L-L	1000V	1000V	1800V
N-G	700V	700V	1000V

12. ANSI/IEEE C High Let-Through Voltage – The let through voltage based on an ANSI/IEEE C62.41 Category C High waveform (10kV, 10kA) shall not exceed the following:

Mode	208Y/120	240/120	480Y/277
L-N	560V	560V	960V

13. ANSI/IEEE Cat. B Ringwave Let Through Voltage – The let-through voltage based on an ANSI/IEEE C62.41 Category B ringwave (6 kV, 500 amps) shall not exceed the following:

Mode	208Y/120	240/120	480Y/277
L-N	160V	160V	165V

#### SPD Design:

14. Maintenance Free Design – The SPD shall be maintenance free and shall not require any intervention throughout its life. SPDs containing items such as replaceable modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.
15. Balanced Suppression Platform – The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression platform must provide equal impedance paths to each matched MOV. Designs incorporating replaceable SPD modules shall not be accepted.
16. Electrical Noise Filter – Each unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be up to 50 dB from 10 kHz to 100 MHz using the MIL-STD-220A insertion loss test method. Products unable able to meet this specification shall not be accepted.
17. Internal Connections – No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be soldered, hardwired with connections utilizing low impedance conductors.
18. Monitoring Diagnostics – Each SPD shall provide the following integral monitoring options:

Protection Status Indicators - Each unit shall have a green / red solid-state indicator light that reports the status of the protection on each phase.

For wye configured units, the indicator lights must report the status of all protection elements and circuitry in the L-N and L-G modes. Wye configured units shall also contain an additional green / red solid-state indicator light that reports the status of the protection elements and circuitry in the N-G mode. SPDs that indicate only the status of the L-N and L-G modes shall not be accepted.

For delta configured units, the indicator lights must report the status of all protection elements and circuitry in the L-G and L-L modes.

The absence of a green light and the presence of a red light shall indicate that damage has occurred on the respective phase or mode. All protection status indicators must indicate the actual status of the protection on each phase or mode. If power is removed from any one phase, the indicator lights must continue to indicate the status of the protection on all other phases and protection modes. Diagnostics packages that simply indicate whether power is present on a particular phase shall not be accepted.

Remote Status Monitor – The SPD must include Form C dry contacts (one NO and one NC) for remote annunciation of its status. Both the NO and NC contacts shall change state under any fault condition.

Surge Counter – The SPD shall be equipped with an LCD display that indicates to the user how many surges have occurred at the location. The surge counter shall trigger each time a surge event with a peak current magnitude of a minimum of  $50 \pm 20A$  occurs. A reset pushbutton shall also be standard, allowing the surge counter to be zeroed. The reset button shall contain a mechanism to prevent accidental resetting of the counter via a single, short-duration button press. In order to prevent accidental resetting, the surge counter reset button shall be depressed for a minimum of 2 seconds in order to clear the surge count total.

The ongoing surge count shall be stored in non-volatile memory. If power to the SPD is completely interrupted, the ongoing count indicated on the surge counter's display prior to the interruption shall be stored in non-volatile memory and displayed after power is restored. The surge counter's memory shall not require a backup battery in order to achieve this functionality.

#### 19. Overcurrent Protection

The unit shall contain thermally protected MOVs. These thermally protected MOVs shall have a thermal protection element packaged together with the MOV in order to achieve overcurrent protection of the MOV. The thermal protection element shall disconnect the MOV(s) from the system in a fail-safe manner should a condition occur that would cause them to enter a thermal runaway condition.

#### 20. Fully Integrated Component Design – All of the SPD's components and diagnostics shall be contained within one discrete assembly. SPDs or individual SPD modules that must be ganged together in order to achieve higher surge current ratings or other functionality shall not be accepted.

#### 21. Safety Requirements

SPDs designed to interface with the electrical assembly via conductors shall require no user contact with the inside of the unit. Such units shall have any required conductors be factory installed.

## **SYSTEM APPLICATION:**

The SPD applications covered under this section include distribution and branch panel locations, motor control centers (MCC), switchgear, and switchboard assemblies. All SPDs shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category C, B, and A environments.

Surge Current Capacity – The minimum surge current capacity the device is capable of withstanding shall be as shown in the following table:

Minimum surge current capacity based on ANSI / IEEE C62.41 location category			
CATEGORY	Application	Per Phase	Per Mode
C	Service Entrance Locations (Switchboards, Switchgear, and MCC)	250 kA	125 kA
B	480 VAC Distribution Panelboards	160 kA	80 kA
A	208/120, 240/120 VAC Panelboards	120 kA	60 kA

SPD Type – all SPDs installed on the line side of the service entrance disconnect shall be Type 1 SPDs. All SPDs installed on the load side of the service entrance disconnect or separately derived system first overcurrent device shall be Type 1 or Type 2 SPDs. All SPDs installed in panelboards shall be Type 2.

Service entrance rated SPD units shall be compliant with UL requirement to receive a lightning protection Master Label Certificate of compliance for lightning protection system as outlined in section 16601.

## **LIGHTING AND DISTRIBUTION PANELBOARD REQUIREMENTS:**

The SPD application covered under this section includes lighting and distribution panelboards. The SPD units shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category B environments.

22. The SPD shall not limit the use of through-feed lugs, sub-feed lugs, and sub-feed breaker options.
23. SPDs shall be installed immediately following the load side of the main breaker. SPDs installed in main lug only panelboards shall be installed immediately following the incoming main lugs.
24. The panelboard shall be capable of re-energizing upon removal of the SPD.
25. The SPD shall be interfaced to the panelboard via a direct bus bar connection or a circuit breaker for disconnecting purposes as indicated on the Contract Drawings. The SPD shall be located directly adjacent to the disconnecting circuit breaker.



26. The SPD shall be included and mounted within the panelboard by the manufacturer of the panelboard.
27. The SPD shall be of the same manufacturer as the panelboard.
28. The complete panelboard including the SPD shall be UL67 listed.

#### Switchgear, Switchboard and MCC Requirements

29. The SPD application covered under this section is for switchgear, switchboard and MCC, locations. Service entrance located SPDs shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category C environments.
30. The SPD shall be of the same manufacturer as the switchgear, switchboard and MCC.
31. The SPD shall be factory installed inside the switchgear, switchboard and/or MCC, at the assembly point by the original equipment manufacturer.
32. Locate the SPD on the load side of the main disconnect device, as close as possible to the phase conductors and the ground/neutral bar.
33. The SPD shall be interfaced to the equipment via a direct bus bar connection or a circuit breaker for disconnecting purposes as indicated on the Contract Drawings. Connection shall be made via bus, conductors, or other connections originating in the SPD and shall be kept as short as possible.
34. The SPD shall be integral to switchgear, switchboard and/or MCC, as a factory standardized design when indicated on the Contract Drawings..
35. All monitoring and diagnostic features shall be visible from the front of the equipment.

#### **SHOP TESTING:**

Provide a factory performance test for each unit. The tests shall be in accordance with the latest version of NEMA and UL Standards:

### **PART 3 - EXECUTION**

#### **3.01 INSPECTION**

- A. Visually inspect delivered unit(s) and accessories for conformance with the Contract Drawings and Specifications.

#### **3.02 INSTALLATION**

- A. Install unit in compliance with the manufacturer's printed instructions. All electrical installation Work shall be in accordance with UL Listing Requirements and National, State, and Local Electrical Codes.

#### **3.03 CHECKOUT AND TESTING**

- A. Provide checkout filed and functional testing in accordance with Section 16050 and 16998.

## **PART 4 MEASUREMENT AND PAYMENT**

### **4.01 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of the surge protection devices.

**END OF SECTION**

## **SECTION 16450**

### **GROUNDING**

#### **PART 1 - GENERAL**

##### **1.1 DESCRIPTION OF WORK**

- A. This Section specifies furnishing and installing complete system neutral grounding and equipment grounding in accordance with Standard Specifications Construction, Section 16450, except as modified herein.
- B. Applicable sections and requirements of Section 16050, Basic Materials and Methods for Electrical Work; and Section 16500 Lighting, shall apply to the work furnished and installed under this Section.
- C. The work under this section shall include furnishing all labor, materials, equipment, and services necessary to construct and install the complete electrical grounding connections and system as shown on the Contract plans and specified herein. This shall include all ground wire, ground rods, and incidentals necessary to provide a complete grounding system.

##### **1.2 SUBMITTALS**

- A. As-Built Drawings. Submit prior to final acceptance of the work, drawings showing complete layout of systems installed including physical location of ground rods to which connections were made.
- B. Field Quality Control Test Report. Submit reports complying with requirements of Part 3 "Field Quality Control" Article.
- C. Catalog cuts and descriptive literature for materials specified herein and as shown on the Contract Drawings.

#### **PART 2 - PRODUCTS**

##### **2.1 BARE GROUND WIRE**

- A. Grounding shall be accomplished in conformance with the relevant provisions of Section 16450. The Contractor shall furnish and install bare copper stranded grounding wire No. 4 AWG. and bond as shown on the plans. A copper clad steel ground rod, 10 feet long by 3/4 inch diameter shall be provided at each lighting pole and control cabinet.

##### **2.2 INSULATED GROUND WIRE**

- A. Copper, Class B Stranded, 600-Volt, 90 degree C, NEC type THWN; meeting requirements of AAR Specifications No. 535.2; sized as indicated; and UL listed.

## **2.3 PRODUCTS USED FOR COPPER THERMIT WELDED CONNECTIONS**

- A. Use products for copper thermit welded connections which are the products of one manufacturer and are produced for the specific application for which they are used.
- B. Use materials and equipment which meet or exceed the applicable acquirements of the AAR Manual, Electrical Section, Section 13, Chapter 3, Part 6.
- C. Coating Materials for Thermit Welded Connections: Use black, rubber based compound coating materials, which are soft, permanently pliable, moldable, and unbacked, not less than 1/8 inch thick, with properties as follows:

Solids	100 percent
Density	12.0 pounds per gallon minimum
Penetration	90-130 ASTM D5
Water Absorption	0.10 percent maximum ASTM D570
Dielectric Strength	500 volts/mil ASTM D149
Volume Resistivity	2,000 megohms-inches ASTM D257 5,000 megohms-cm ASTM D257
Service Temperature	Minus 40 degrees to 160 degrees F.
Chemical Resistance	Melting point, none; flammability, slow burning (ASTM C653); resists alcohol, water, aqueous hydrochloride and sodium hydroxide; dissolved by carbon tetrachloride, naphtha gasoline, mineral spirits, ketones, and benzene.
Highly cohesive and Adhesive	Adheres strongly to metals and concrete and to itself.

## **2.4 BOLTED GROUNDING CONNECTORS**

- A. For solderless type made of high strength electrical bronze with silicon bronze clamping bolts and hardware; designed such that bolts, nuts, lock washers and similar hardware which might nick or otherwise damage the ground wire will not directly contact the ground wire.

## **2.5 GROUND RODS**

- A. Medium carbon steel core, copper clad by the molten weld casting process; sizes as shown on the Contract Drawings; UL approved.

# **PART 3 - EXECUTION**

## **3.1 PREPARATION**

- A. Perform testing as specified in Part 3 "Field Quality Control" Article.

### **3.2 GENERAL GROUNDING REQUIREMENTS**

- A. General. Provide station electrical grounding complying with procedures of NEC and as indicated.
- B. Equipment Ground Conductors
  - 1. Provide each conduit entering switchgear with equipment ground conductor, colored green.
  - 2. Terminate conductor directly on ground bus for power equipment housing and conduit system; do not connect equipment ground conductor to neutral bus. Additionally, do not use these conductors to carry any line-to-ground loads, such as 240 volt lighting.
  - 3. Provide feeders serving single phase 120/240 volt loads with one equipment ground conductor.
- C. White Neutral Conductor. Provide each conduit feeding line-to-ground loads, such as 120 volt control power with both an equipment ground conductor and insulated white neutral conductor.
- D. For the Power and Communications Shed, provide grounding for the 120/240V distribution panels (total of 2) and communications ground bus.
- E. For the Transformer, Metering Cabinet Power and Communications Shed, provide grounding for the 120/240V disconnect switches, 120/240V distribution panel, and associated equipment.
- F. For the Prefabricated Maintenance Building, provide grounding for the 120/240V distribution panels (total of 2).
- G. Provide convenience outlets having ground fault circuit breakers, complying with Section 16050 – BASIC MATERIALS AND METHODS FOR ELECTRICAL WORK.

### **3.3 EQUIPMENT GROUNDING**

- A. At Power Shed, ground system as indicated in contract drawings.
- B. Lighting Fixtures and Equipment .
  - 1. Accomplish grounding with equipment ground.
  - 2. Provide equipment ground conductor electrically and mechanically continuous from system equipment and neutral ground connection at source of supply to equipment to be grounded.
  - 3. Provide copper equipment ground conductor minimum one size smaller than phase conductors, except having minimum size of No. 12 and maximum size No. 4/0 AWG.
  - 4. Identify equipment ground conductors with colored green type THW insulation, except where green insulation is not available on larger sizes, black colored insulation shall be used and suitably identified with green tape at each junction box or device enclosure.
- C. Junction Boxes and Other Enclosures Sized Above Five Square Inches. Securely bond equipment ground conductors to enclosures utilizing equipment ground bus or lug.
- D. Ground Electrodes (Rods)
  - 1. Ground rods shall not protrude above finished grade to prevent a tripping hazard.

E. Grounding Conductors

1. All direct buried grounding conductors comprising of the main ground grid for the new power and communications sheds and control cabinets/enclosures and transformer pads shall be installed a minimum of 30 inches below finished grade or ballast.
2. Separate grounding conductors shall be provided for all circuits as required by these Specifications and as indicated on the Contract Drawings

F. Ground Terminations

1. All ground rod electrical connections should be welded with the CADWELD copper-based exothermic welding process. Exothermic welds shall adhere to manufacturers instructions. Exothermic welds shall be Erico or approved equal

G. Electrical Handole Frames

1. Electrical handhole frames shall be grounded as shown on the Contract Drawings.

H. With each cable run, an equipment ground conductor shall be installed to which all equipment shall be bonded in accordance with standard practice and the NEC. Metal conduit, metal poles and pedestals, metal hardware and lighting fixtures, and metal cabinets shall be made mechanically and electrically secure to form a continuous system and shall be effectively grounded to the ground electrode installed at the service point. Bonding of metallic conduit systems in concrete foundations and pull boxes shall be by means of approved grounding bushings (compatible with the conduit) and bonding jumpers. Green Ground Conductor is always required as an equipment grounding conductor. Rigid steel conduit system may not serve as the equipment grounding conductor.

1. The grounding conductor shall also be bonded to the ground electrode placed at each electric handhole.

### **3.4 CONVENIENCE OUTLETS**

- A. Ground all convenience outlets in accordance with the NEC.

### **3.5 THERMIT WELDING CONNECTIONS**

- A. Connect electrical wires together, to reinforcing steel or soldier piles, as indicated, by thermit welding using the manufacturer's recommended molds and size of charges for application.
- B. Prepare the material to be welded and perform thermit welding in accordance with manufacturer's instructions.
- C. Test completed thermit welds before coating by striking with two pound hammer. If cracks develop, replace welds at no additional expense to the Authority. When required by the Engineer, test the electrical continuity of bonds.
- D. Apply coating so that it extends one inch beyond point of attachment to steel member, overlaps wire coating one inch, and provides insulation thickness equivalent to wire insulation, but not less than 1/8 inch in thickness. Do not apply coating material at ambient temperatures below 20 degrees F or above 125 degrees F. Maintain, by an approved method, curing temperature

within above temperature range for at least four hours after application of coating. Protect coating by approved means until embedment.

### **3.6 FIELD QUALITY CONTROL**

#### **A. Control Shed and Control Cabinet/Enclosed Ground System Testing**

1. General. After installation of the main ground grids and ground electrodes and prior to interconnection of other grounding systems, perform ground resistance testing.
2. Test Report. Provide report-giving results of testing procedures, which shall also include temperature, humidity and condition of soil at time of tests.
3. Ground Resistance Testing
  - a. Test Equipment and Method. Perform testing using ground resistance direct-reading single test meter utilizing alternating current fall-of-potential method and two reference electrodes.
  - b. Test Procedure
    - 1) Orient ground electrode to be tested and two reference electrodes in string line spaced minimum 50 feet apart.
    - 2) Drive two reference electrodes five feet deep.
  - c. Resistance Test Value. The maximum allowable resistance value of the grounding system for the new power and communication sheds shall be 1 ohm. If it is found that the resistance value of the grounding system exceeds 1 ohm, the Contractor shall install additional ground rods in series until the resistance value reaches 1 ohm or less. Additional ground rods shall be spaced no less than 10 feet apart. If, after additional ground rods are installed, excessive resistance readings persist, the Contractor shall notify the Engineer.

#### **B. Miscellaneous Equipment Grounding System Testing**

1. Electrical equipment such as power service equipment, electrical manholes and handholes and other electrical apparatus requiring grounding shall meet the resistance test value specified below.
2. Resistance Test Value. The maximum allowable value for electrical apparatus specified above shall be 25 ohms or less. If it is found that the resistance value exceeds 25 ohms, the Contractor shall install additional ground rods in series until the resistance value reaches 25 ohms or less. Additional ground rods shall be spaced no less than 10 feet apart. If after additional ground rods are installed, excessive readings persist, the Contractor shall notify the Engineer

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 MEASUREMENT**

- A. No separate measurement will be made for the work of this Section, but all costs in connection therewith shall be included in the items of work to which it pertains. All preparation and incidental work necessary to accomplish the installation will be considered incidental to the Contract Unit and Lump Sum prices.

**END OF SECTION**



## **SECTION 16471**

### **DISTRIBUTION AND BRANCH CIRCUIT PANELBOARDS**

#### **PART 1 - GENERAL**

##### **1.1 DESCRIPTION OF WORK**

- A. Work Included: This Section specifies distribution and branch circuit panelboards and panelboard enclosures.
- B. Related Work- Related work should be performed under sections 16050-Basic Methods for Electrical Work, and 16450-Grounding.

##### **1.2 SUBMITTALS**

- A. Submit for approval catalog cuts, drawings, and data, for each item, indicating the following:
  - 1. Manufacturer's model number or item identification.
  - 2. UL listing and rating.
  - 3. Critical dimensions and mounting arrangements.
  - 4. Complete replacement parts list.
- B. Enclosures: Materials and methods of construction, door arrangement, conduit hub and knockout locations, and identification of intended panelboard.
- C. Circuit Breakers: Circuit for which intended, voltage ratings, insulation level, current rating, and interrupting ratings.
- D. Panelboards: Base material, general arrangement, location and identification of each circuit breaker and the circuit breaker information specified above, location and identification of all terminals, location of barriers, applicable UL 67 Tables A through F information, wiring diagrams, and identification of the enclosure for which intended.

##### **1.3 QUALITY ASSURANCE**

- A. Manufacturing: Manufacturer's and UL standard inspecting and testing procedures.
- B. UL Labels
  - 1. Each factory-assembled enclosure panelboard.
  - 2. Each panelboard shipped separately.
  - 3. Each circuit breaker shipped for field mounting.
- C. Listing and Special Marking
  - 1. Each enclosure shipped separate from panelboard shall be UL listed and marked with the identification of the panelboard for which intended.
  - 2. Raintight marking for all enclosures exposed to weather or unusual spray or moisture conditions.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL**

- A. Distribution and branch circuit panels shall be enclosed, completely factory assembled type unless otherwise approved, dead-front grounded enclosure complete with circuit breakers as shown on the Contract Drawings. Design and assemble interiors so that any individual breaker can be replaced without disturbing adjacent units or without removing main bus connectors. Design main buses and back pans of distribution panelboards such that branch circuits may be changed without additional machining, drilling or tapping. Provide cutout type only where specifically indicated.
- B. Materials of construction: UL 67; appropriate NEMA Standards, UL listed.
- C. Field Wiring and Miscellaneous Hardware: Section 16050 – BASIC MATERIALS AND METHODS FOR ELECTRICAL WORK and Section 16450 - GROUNDING, UL listed.
- D. Field Touch-up or Repainting Paint: As recommended by enclosure manufacturer.

### **2.2 CIRCUIT BREAKERS**

- A. Main Circuit Breaker shall have an interrupting rating not less than 20,000 amperes rms symmetrical or as otherwise indicated. The breaker trip element; enclosed compensated for temperature rise and calibrated to 40°C ambient temperature.
- B. Circuit breakers shall be of the indicating type, providing "on", "off", and "tripped" positions of the operating handle. When the breaker is tripped automatically, the handle shall assume a middle position between "on" and "off". All multi-pole breakers shall be so designed that an overload on one pole automatically causes all poles to open. The circuit breaker shall be quick-make and quick-break on manual as well as automatic operation and shall have inverse time characteristics secured through the use of a bimetallic tripping element supplemented by a magnetic trip.
- C. The branch circuit breakers shall have fixed thermal-magnetic trips, of values shown on the Contract Drawings, and shall have minimum UL listed interrupting ratings of 10,000 symmetrical amperes at 240/120 Volts. All breakers shall be bolt-on type.
- D. Provide handle "lock-on" devices on the circuit breakers indicated on the schedules. "Lock-on" devices shall prevent accidental deenergization of critical circuits. These devices shall be trip-free, permitting the circuit breaker to trip automatically on overload. Provide one "lock/on" device for every four circuit breakers indicated in the lighting and power panels. Furnish the Authority for future use all "lock-on" devices not installed.
- E. All circuits, which serve convenience outlets, shall be protected by ground fault circuit breakers for personnel protection.

### **2.3 ENCLOSURES**

- A. Panel type with butt hinged door or doors with cylinder housing capable of receiving cylinder specified in Section 08711 - DOOR HARDWARE. Trim must also be hinged.
- B. Mark enclosures for easy identification of intended panelboard unless panelboard is shipped factory installed.

- C. Enclosures for mounting exposed to the weather or in unusually wet locations shall be rainproof type, and so marked. All others shall be standard type.
- D. Directory: Card type, suitable for typewriting directory of circuits, mounted under unbreakable transparent protective cover set in metal frame on inside of door, with provisions for:
  - 1. Panel designation and panel or switchboard from which panel is fed.
  - 2. For each circuit breaker, complete information concerning the circuit controlled, including the voltage and the area, room number, or appliances served; or Main or Spare as applicable.
- E. Finish: Thoroughly cleaned, phosphatized or equivalent, coated with at least one coat of corrosion resisting paint inside and out suitable for the material, and painted with manufacturer's standard electrical grey paint suitable for touch-up or repainting in the field.

## 2.4 PANELBOARDS

- A. UL listed and UL labeled unless shipped as a factory-mounted component of a UL labeled enclosed type panelboard with bases not over 48 inches top edge to bottom edge.
- B. Interrupting Devices: Circuit breaker type except where cutouts, meter fuses, or switches are specifically indicated. All cutouts, fuses and pull-out type UL listed.
- C. Panelboards, where shown on the Contract Drawings, shall be equipped with a main protective device consisting of a three-pole switch and current limiting fuses. Ratings shall be as indicated on the panelboard schedules.
- D. Panelboards shall be furnished with an insulated solid neutral bus and a suitable grounding, bus-connected to interior of panel enclosure for termination of green equipment grounding conductor.
- E. Panelboards shall have provisions, including space, terminals, and bus capacity, for future addition of at least one and not less than 10% of the total outlet circuit breakers of each rating. Close extra spaces with spare breakers.
- F. Terminals: Rated solderless type, suitable for either copper conductors sized at maximum rated terminal capacity.
- G. Buses and Connecting Straps: Solid copper, main bus rated at the sum of the branch circuit ratings, including motor loads in accordance with Section 430-24 of the National Electrical Code plus 100% of the sum of the trip ratings of the spares specified in paragraphs above, but in no case less than specified in UL 67. Full neutral bus and separate ground bus.
- H. Color markings per optional provision UL 67, Paragraph 143.
- I. Marking for easy identification of intended enclosure unless shipped factory mounted in enclosure.
- J. Permanent numerical identification by each breaker space.
- K. Spare breaker spaces closed with spare breaker. Must provide space for 50% spare breakers.

- L. Panelboard cabinets shall have means for securing, supporting, and adjusting the panelboards and trim.
- M. Panelboard gutter space shall be as required by the NEC.
- N. Where gutter spaces are occupied by feeder cables, gutter spaces shall be increased as required.
- O. Panelboard cabinets shall be ordered without knockouts.
- P. Panelboards shall be furnished with an insulated solid neutral bus and a suitable grounding bus connected to interior of panel enclosure for termination of green equipment grounding conductor.
- Q. All panelboard covers and doors must be hinged.

## **2.5 ENCLOSED PANELBOARDS**

- A. Conform to requirements specified in Part 2 “Panelboards” Article.
- B. UL Enclosed Panelboard Label: Form 6, Form 12, or general. Enclosed cutout label only where cutout is specifically indicated.

## **2.6 POWER PANELBOARDS**

- A. Power panelboards shall be 120/240 Volt, single phase, three wire.

## **2.7 LIGHTING PANELBOARDS**

- A. Miscellaneous power and lighting panelboards shall be 120/240 volt, single phase, three wire, and shall have single pole, 120 Volt, bolt-in type molded case circuit breakers in the quantities and sizes indicated.

## **2.8 MISCELLANEOUS POWER AND LIGHTING PANELBOARDS**

- A. Miscellaneous power and lighting panelboards shall be 120/240 Volt, single phase, three wire and shall have 10,000 Amp interrupting capacity bolt-in molded case circuit breakers in the quantities and sizes indicated.

# **PART 3 - EXECUTION**

## **3.1 GENERAL**

- A. Prior to commencing installation, verify that all surfaces upon or in which enclosures are to be mounted are properly prepared and that all pre-mounting wire pulling has been completed and properly tagged. Take corrective action if necessary.
- B. Verify that enclosure mounting provisions are suitable for intended mounting. Make corrective adjustments, if necessary.

- C. Verify that all factory-installed circuit breakers are correct rating for the applicable circuit application as indicated. Take corrective action if necessary.
- D. Install panelboards in enclosures in accordance with manufacturer's instructions, if practicable before mounting enclosure.
- E. Complete all directory cards with the information indicated in Part 2 "Enclosures" Article above. Typewrite information on directory cards.

### **3.2 ENCLOSURES AND PANELBOARDS**

- A. Install at indicated or approved locations in accordance with manufacturer's instructions, and at convenient operating height such that no manually operable device will be within 2- 1/2 feet of the floor or more than 6-1/2 feet above the floor, and so that the mid-point of all manually operable devices is as nearly as practicable 5-1/2 feet above the floor without exceeding the above maximum height limitations.
- B. Adjust straight and plumb and fasten securely in place. Align and securely and independently fasten each section of multi-section enclosures.

### **3.3 WIRING**

- A. Perform wiring in accordance with Section 16050 – BASIC MATERIALS AND METHODS FOR ELECTRICAL WORK, and UL 67; NFPA 70, Article 240; and manufacturer's instructions.
- B. Perform circuit wiring as specified in Section 16050 – BASIC MATERIALS AND METHODS FOR ELECTRICAL WORK.
- C. Ground as specified in UL 67; NFPA 70, Articles 200 and 250; and Section 16450 - GROUNDING. Connect neutral wire directly to neutral bus, and ground wire to ground bus, in same panel as circuit interrupting device.
- D. Neatly route, harness and support conductors in gutters, wiring spaces and compartments. Bending radii not less than recommended by conductor manufacturer.
- E. Verify that circuits are wired as indicated and are continuous and free of shorts. Energize, as permitted by the Engineer, and test each circuit, including lights and outlets. Check voltage at outlets. Test other electrical equipment as recommended by manufacturer. Measure ground bus and grounded conductor resistance to true ground, resistance between enclosure and ground bus, between pairs of bus bars, and between insulation and ground bus. Resistances shall be within limits specified in Part 3 "Acceptance Tests" Article. If resistances are not within the limits specified, the cause of such resistances shall be determined and corrective action shall be taken to obtain the acceptable resistances specified.
- F. Install bonding jumpers from conduits entering cabinets to ground bus.

### **3.4 ACCEPTANCE TESTS**

- A. Repeat the tests specified in Part 3 "Wiring" Article in the presence of and to the satisfaction of the Engineer. Test operation of each circuit and circuit control a minimum of 10 times and

operation of each circuit continuously for a minimum of 1/2 hour. For all lighting circuits, comply with additional requirements specified in Section 16500 - LIGHTING.

**B. Acceptable Resistances**

1. Ground Bus and Grounded Conductor to True Ground: 2 Ohms maximum.
2. Between Pairs of Bus Bars: 50,000 Ohms minimum.
3. Between Insulation and Ground Rod: 10 Megohms minimum.

**PART 4 - MEASUREMENT AND PAYMENT**

**4.1 GENERAL**

- A. Separate measurement and payment will not be made for work required under this section, but all costs therefore shall be incidental to the item or items of work to which they pertain.

**END OF SECTION**

## **SECTION 16500**

### **LIGHTING**

#### **PART 1 - GENERAL**

##### **1.1 DESCRIPTION OF WORK**

- A. This Section specifies the furnishing and installing of area lighting systems at various locations, complete as indicated, including walkways, roadways, and BRT Stations, with all lighting fixtures with lamps and ballasts, poles and mounting brackets, hardware, foundations, feeder and branch wiring systems including conduit, wire, splices and terminations, excavation, backfill and compacting for foundations and poles, and conduit systems, hardware and fittings, panel board circuit breakers, power disconnect switches, contactors and control components, wire ways, aerial cable and messenger wire, light poles, pole fittings & hardware, brackets, ground rods, ground wire, ground connectors, clamps and components, and installation of electrical control and protection components, and testing of completed systems.
- B. Applicable sections and requirements of Section 16050, Basic Materials and Methods for Electrical Work; and Section 16450, Grounding; shall apply to the work furnished and installed under this section.
- C. The work under this section shall include furnishing all labor, materials, equipment, and services necessary to construct and install the complete lighting system as shown on the Contract plans and specified herein. This shall include all lighting standards with brackets and foundations, all necessary mounting hardware, light fixtures with luminaires, ballasts, lampholders, lamps, wiring from the feeder to the luminaires connections and all incidentals necessary for a complete area lighting system
- D. The work under this Section shall be performed in conjunction with the relative provisions of Section 820 of the MassDOT Highway Division Standard Specifications for Highways and Bridges, and the Special Provisions contained herein.
- E. The work also includes relocation of existing light poles and appurtenances in the parking lot at 200 Arlington Street, Chelsea, as indicated on the Plans.

##### **1.2 SUBMITTALS**

- A. Submit shop drawings, exploded view assembly drawings, catalog cuts, descriptive information for all lighting fixtures, lamps, ballasts, capacitors, ignitors, auxiliary lighting equipment, lighting control equipment, contactors and lighting controls, and mounting hardware for each product type specified..
- B. Submit manufacturer's installation instructions detailing the installation procedures and recommended maintenance procedures that will comply with the warranty specified.
- C. The manufacturer must provide photometric data certified by an Independent Testing Laboratory for each fixture type specified. Data must include the following information:
  - 1. Horizontal Illumination diagram for each mounting height specified on the drawings

- displaying lumens per square foot, ½ Maximum Candela Trace, and the location of the Maximum Candela Trace.
2. Candela Tabulation
  3. Coefficients of Utilization and Flux Distribution Analysis
  4. Maximum Plane and Maximum Cone of Candela
  5. IES formatted photometric data on a 3 ½" diskette (DOS-ASCII Format), prepared by an Independent Testing Laboratory.
  6. All data submitted must have been prepared within the past five years.
- D. Pole submittal shall include professional certification that each arrangement (or assembly) conforms to the requirements of this specification before commencement of any manufacturing of product for the project. Certification shall include all apparatus that will be mounted to the poles directly including materials supplied by other trades.
- E. Manufacturer to provide documentation that all fixtures are listed by Underwriters Laboratories, Inc. and state that the fixtures being submitted will operate properly for each mounting condition shown throughout the Contract Drawings.
- F. The manufacturer shall provide for the areas to be illuminated, a computerized printout (in drawing form) detailing the entire finished area(s) on Contract Drawings that are being lighted by the submitted luminaires and a statistical summary of maintained illumination levels at grade by means of a grid spaced no further than five (5) feet on center at a scale of 1"=20'-0" accompanied by a copy of all input data used to create the drawing(s). These calculations shall be reviewed by the Engineer. The manufacturer will be responsible for meeting the criteria regarding minimum and average illumination levels. The Engineer shall be the sole judge as to acceptability.
1. Submit an illumination matrix for the parking area and roadway area to represent accurate average footcandles and uniform ratio with a mounting heights, lamp wattage and spacing as shown on the Contract Drawings. The matrix shall be based on luminaires aimed and tilted to provide optimum illumination on the roadway surface, walkways, and stations. Aiming direction and tilt are to be shown for each fixture for guidance in the installation.
  2. Use a maintenance factor of 0.75 for all lighting submittals.
  3. Submit a shop drawing of the lighting contactor including a control component layout, detail of field circuit terminations, a control wiring diagram, and proposed labeling.
- G. The Contractor shall provide signed affidavits from a master electrician who has supervised such electrical installations on a regular basis, stating that the installation is in compliance with the Massachusetts Electrical Code.

### **1.3 QUALITY ASSURANCE**

- A. Fixtures and auxiliary equipment shall be listed, labeled or certified by UL.
- B. Replace lamps, which fail within 90 days after final acceptance, at no cost to the Owner.
- C. Installation Tolerances: Deviation from location, alignment and mounting height: 1/2 inch noncumulative in any unit or continuous run of fixtures.
- D. Warranty



The manufacturer shall comply with the following warranty:

1. The manufacturer warrants that the design, material and workmanship incorporated in each luminaire shall be of the highest grade and consistent with established, and generally accepted, standards for lighting application.
2. The manufacturer agrees that this warranty shall commence with the acceptance of the luminaires, whether a defect is patent or latent, and shall continue for a period of five (5) years non-prorated after acceptance by the MBTA.
3. The manufacturer will be allowed to inspect, at no cost to the Authority with the Engineer present, the installation of the product in order for the final issuance of the warranty. Should any modifications be required regarding the installation of the product(s), it will be at the Installing Contractor's expense. Once all modifications are accepted by the manufacturer, the product warranty will become effective and supported by the manufacturer.
4. Any claims against the warranty will be valid regardless of who performs the installation. The manufacturer will be allowed to inspect after the time the repair has been made, at no cost to the Authority with the Engineer present, the installation of the product in order for the final issuance of the warranty.

#### **1.4 PRODUCT DELIVERY, STORAGE & HANDLING**

- A. The Manufacturer is required to ship the lighting fixtures, poles, and accessories securely packaged and labeled for safe handling during shipment to avoid damage or distortion.
- B. The Contractor is responsible for storing lighting fixtures, poles and accessories in a secure and dry facility and in original packaging to prevent soiling, physical damage, wetting or corrosion prior to installation.
- C. Contractor must provide for storage inspection by the Engineer after fixtures have been delivered.

#### **1.5 DESCRIPTION OF ILLUMINATION**

- A. Roadway and walkways (including the Shared Use Path) shall be illuminated to a maintained minimum horizontal footcandle level of two (2) footcandles with an average/minimum footcandle uniformity ratio of 4:1 or better at the roadway and walkway surfaces.
- B. The Bus Rapid Transit Station platform and waiting areas shall be illuminated to a maintained minimum horizontal footcandle level of Twenty (20) footcandles with an average/minimum footcandle uniformity ratio of 4:1 or better at the station waiting area surface.

### **PART 2 - PRODUCTS**

#### **2.1 LIGHTING FIXTURES**

- A. General Requirements

1. Provide lighting fixtures, complete and ready for service, in compliance with UL 57, of the number, type, material, finish, electrical components and characteristics, and with all necessary hardware and auxiliary equipment indicated.
2. The fixtures shall be clearly marked with manufacturer's name and catalog number, voltage, acceptable lamp type, maximum wattage, ballast type, and self-protection, if any. The fixtures shall be identified with standard lamp type and wattage on the exterior of the fixture housing visible from ground level. Two-inch adhesive labels with a number indicating wattage and color signifying lamp type shall be provided.
3. Fixtures shall be rain-tight and dust-tight for use along trackways, for outdoor use, and as indicated. Fixtures must meet IP55 test for water and dust.
4. Fixtures shall be of the same design shape and supplied by the same manufacturer. Luminaires for the project are broken down as follows:
  - a. The Busway will use 100 watt light emitting diode (LED) luminaires
  - b. Sidewalks and the Shared Use Path will use 100 watt LED luminaires
  - c. BRT Station Canopies will use a 400 watt metal halide luminaire with a fixture (housing) dimension as shown on the contract drawings. Canopy fixtures are to be UL approved for raintight use.
  - d. Abutment mount fixtures will use a 100 watt LED wall pack with a fixture (housing) dimension measuring approximately 9" x 18" x 10".
5. Performance Criteria
  - a. Luminaire shall be UL and CUL listed for wet locations.
  - b. Housing Size shall be rectangular.
  - c. Lamp Wattage and Type shall be 400 watt metal halide suitable for horizontal and vertical mounting.
  - d. Voltage shall be Multi-voltage (120 through 480) and which includes operation suitable for 480 volts.
  - e. Beam pattern shall be IES Type Distribution
  - f. Mounting arms and brackets shall be as shown on Contract Drawings.
  - g. Color shall be Silver Natural Aluminum
  - h. Double fusing shall be provided
  - i. Fixture shall consist of mounting, optical, support, and electrical systems.
  - j. Housing shall be one piece formed aluminum with smooth welded seams.
  - k. Lens shall be minimum 1/8 inch thick clear tempered flat glass attached to the door frame.
  - l. Exterior surface finish shall be a fade resistant silver natural aluminum polyester power paint baked on to provide a hard durable coating.
  - m. Optical system shall provide a fully reflective interior constructed of an enhanced pre-anodized aluminum.
  - n. The electrical system shall consist of ballast and components attached to a tray. The tray shall be removable without the use of tools. Ballast factor shall be 1.0
6. Finishes of fixtures shall be silver natural aluminum. Thermoset Polyester Powder-Coat 2.5 Mil nominal thickness paint applied over a chromate conversion coating.
7. Ballasts for fixture with 400-watt metal halide, 480 volts shall be of the lead circuit design. Primary voltage shall be 480 volts. Lamp operating watts shall not average below rated watts over the life of the lamp and power factor shall not average below 90% over the life of the lamp. Substitute ballasts for those specified shall have a current "volts/watts trace life cycle" test performed by an approved electrical test laboratory.

8. Fixtures shall have tool-less quick disconnects for electrical assembly or tool-less removable unitized galvanized steel ballast tray to allow ease of maintenance.
9. Lighting Poles shall be 6" square aluminum as shown on the Contract Drawings.

**B. Materials**

1. Thicknesses, gauges and tempers of products: indicated, and as recommended by the manufacturer for the specific finish, proper forming operations and structural requirements.
2. Lighting sheet for reflector material: Prefinished aluminum, minimum thickness 0.032 inch, architectural Type 1 with Class M1, anodic coating providing 83% reflectivity.
3. Concrete for base foundations: Section 03300 - CAST-IN-PLACE CONCRETE
4. Acrylic lenses: 100% virgin acrylic plastic.
5. Polycarbonate lenses and diffusers: Injection molded, crystal clear material, polycarbonate.
6. Lenses to be clipped and hinged.

**C. Finishes**

1. Finishes shall be in accordance with the manufacturer's recommendations for the specific application.
2. Commence no finishing operations until fabrication and forming operations have been completed.
3. Aluminum work to be anodized shall be given a preanodic treatment followed by an architectural Class 1, anodic coating as described by the Aluminum Association.
  - a. Anodize aluminum in accordance with procedures established by alloy manufacturer to achieve color within specified range.
  - b. Apply a clear organic protective coating to exposed aluminum surfaces that may experience prolonged contact with caustic material, i.e., concrete, plaster.
4. Baked enamel: Factory applied to clean surfaces prepared with a chromate conversion coating, and prime coating, as indicated.
5. Porcelain enamel coating: In accordance with the requirements of Porcelain Enamel Institute, PEI-S-100.
6. Galvanized coating: Hot-dip galvanized or hot-zinc conforming to ASTM A 386. Where painting of the galvanized surface is indicated, prepare the surface with vinyl acid wash primer with polyvinyl butyral resin 56 pounds, 80 gallons zinc chromate pigment and phosphoric acid.

**D. Electrical Components**

1. Lampholders
  - a. Lampholders and sockets: Class and style recommended by the lamp manufacturer for the specified lamp required by each fixture design and rated for 660 watts, 600 volts or as indicated. Rigidly and securely fastened to the mounting surfaced with the necessary provisions to prevent lampholder from turning and front removable without dismantling any part of the fixture. Located in the lighting fixtures to place each lamp, of size specified, in proper position with relation to the fixture design specified. Clearly marked to indicate manufacturer lamp type and voltage and appropriate listings.
  - b. Incandescent and high intensity discharge (HID) lampholders: Glazed porcelain body with nonferrous metal components of heavy duty design, vibration resistant,

Edison-based lampholders in accordance with the applicable requirements of UL 496.

- 1) Metal halide lamps that are to be operated in the horizontal position:  
Position oriented mogul base socket.

2. Ballasts

- a. Ensure ballast operating characteristics comply with the recommendations of the lamp manufacturer with regard to lamp electrical characteristics. Provide ballasts suitable for the line voltage with 0.9 power factor, and maximum current crest factor of 1.8. The ballast shall provide reliable lamp starting at the minimum temperature indicated, and operate in ambient temperatures up to 105°C with maximum ballast case temperature of 90°C. Each ballast shall be securely mounted inside the fixture, in such a manner as to obtain the necessary heat dissipation. High intensity discharge ballasts shall conform to the applicable requirements of UL 1029. Fluorescent ballasts shall conform to the applicable requirements of UL 935.
- b. Metal halide lamps: Operated by a lead peaked auto, LPA, type ballast. The ballast shall provide reliable single lamp starting at minus 20°F, and allow plus or minus 10 percent lamp watts variation for a plus or minus 10 percent input voltage variation.
- c. High pressure sodium lamps 150 watt size and smaller: Operated by a constant wattage autotransformer, CWA type ballast. The ballast shall provide reliable lamp starting at minus 20°F, and allow plus or minus 5 percent lamp watts variation for a plus or minus 10 percent input voltage variation.
- d. High pressure sodium lamps, 250 watt size and larger: Operated by a constant wattage autotransformer, CWA type ballast. The ballast shall provide reliable lamp starting at minus 20°F, and allow plus or minus five percent lamp watts variation for a plus or minus ten percent input voltage variation.
- e. All ballasts to be magnetic not electronic due to interference caused by traction power sources.
- f. One light fixture per ballast.
- g. Avoid the use of remote ballasts.

3. Fixture Wiring

- a. Fixture Wires: Outdoor rated, Stranded tinned-copper construction, not smaller than No. 16 AWG. Insulation: silicone rubber type SF-2 and 200°C rated. Conductor size, temperature rating, voltage rating and manufacturer clearly marked on the insulation of each conductor.
- b. Use wires between lampholders and associated operating and starting equipment of the same ampacity rating as leads from the ballast. Wiring within the fixtures shall conform to the requirements of the NEC.
- c. Tape wires at all points of abrasion. No splices shall be permitted within fixtures other than as required to connect lampholders and ballasts.
- d. Fixture Grounding. Unless otherwise specified, the housing of each ballasted lighting fixture shall be provided with a separate, factory-installed grounding device. The grounding device is to be used for connecting a separate, green, grounding conductor to the fixture housing.
- e. Wireways and wiring channels shall have rounded edges or bushed holes wherever conductors pass through. Insulated bushings shall be installed at points of entrance and exit of wiring.

E. Fixture Hardware

1. Latch and release mechanism, hinges, pins and other retaining parts of fixtures; screws, bolts or other assembly and mounting parts: manufactured of Type 316 stainless steel. All springs: heavy duty stainless steel. All retaining hardware: self-retaining.
2. Frame light transmitting elements of the fixture to permit replacement of panels in the frames without the use of tools other than screwdriver or pliers. Secure panels in the frames in a neat, rattle-free manner that will provide proper tolerance for normal expansion and contraction.
3. Provide stems for all pendant mounted fixtures of length as required for the specified mounting height with swivel hangers or ball aligners as required.
4. Form gaskets, sealants and adhesives subjected to high temperature from silicone rubber. Provide other gaskets of neoprene, or as indicated.
5. Fasteners: Provide bolts, nuts, washers, screws, nails, rivets and other fastenings necessary for proper erection or assembly of work. When exposed to the atmosphere, provide fasteners made of 18-8 stainless steel. Fasteners within the housing shall be made of zinc plated, bright iridite, steel or electrogalvanized, gray. Nuts shall have captive externally footed lockwashers.

F. Welding

1. Locate welds in assemblies to be anodized to conceal visible discoloration in the heat-affected zone.
2. Where weld metal will be exposed after anodizing, select filler alloys to closely match composition of base metal. Comply with parent metal manufacturer's recommendations for such filler alloys.

## 2.2 FIXTURE MOUNTING HARDWARE

- A. General Requirements. Provide the fixtures with brackets, straps, canopies and stems, poles and miscellaneous hardware outdoor rated and suitable for the mounting method specified.
- B. Secure mounting brackets to housing, quantity and spacing as indicated. When exposed to public view, fabricate and finish hardware in matching material to fixture body. Fabricate internal brackets from sheet steel, zinc coated after fabrication.
- C. Canopies, holders and similar parts shall be drawn or spun in one piece with a minimum 0.026 inch finished thickness.
- D. Tubing used for supporting member shall be seamless drawn with a minimum of 1/16 inch wall thickness of size and length as indicated.
- E. Light poles: Of the type, configuration and dimensions, indicated. The pole shall resist wind loads of 90 mph with a maximum deflection of five percent when fully loaded by their own weight, weight and wind resistance of luminaires they support, and any externally applied loads. Furnish poles as indicated with four by six inch handhole with flushcover, luminaire mounting (tenon/bracket), base cover and all mounting hardware including anchor bolts, nuts, washers and baseplate to permit accurate alignment and installation of pole and luminaire as indicated. All wiring splices to be located above ground. All exterior light poles to have a minimum 24 inch concrete base for protection from snow plows.
- F. General Requirements:
  1. Poles shall be wood as shown on Contract Drawings.

2. Poles shall meet the latest AASHTO Standards for Highway Signs, Luminaires and Traffic Signals for a wind speed of 90 MPH.
3. Poles shall be provided with mounting brackets suitable for mounting the number and Type of fixtures specified at each pole location. Bracket shall be galvanized steel.
4. Wiring shall be by aerial cable as shown on Contract Drawings.
5. The pole manufacturer and/ or Professional Engineer shall provide complete design wind calculations with consideration for snow and ice loading, along with the shop drawing submittals. The poles shall be approved by the Engineer prior to ordering. All shop drawings shall be stamped by a Professional Engineer registered in the Commonwealth of Massachusetts. Calculations shall be provided for new lighting poles, with new lighting fixtures and new aerial cable installed. Calculations shall be provided for existing poles with new aerial cable added. Refer to Contract Drawings

## **2.3 LAMPS**

- A. General Requirements. Provide each lighting fixture with the number, type, and wattage of lamps required by the Contract Drawings. Provide lamps of standard manufacture, readily available, and of the highest efficiency and life consistent with other requirements of the illumination system.
- B. Metal Halide Lamps: Clear and provided with position oriented mogul bases. Photometric characteristics shall provide lamp maximum luminous output while lamp operates in the vertical position.
- C. The 400-watt metal halide lamp shall be clear, having a minimum 32,000 lumen initial output and a minimum average rated life of 15,000 hours.
- D. Provide an additional 10% spare of each type of lamp installed.

## **2.4 AUXILIARY LIGHTING EQUIPMENT**

- A. General Requirements. Auxiliary lighting equipment intended to supply illumination in the event of failure of normal power supply: Conform to the applicable requirements of UL924, NEC, MBTA Life Safety Code, NFPA-101, Massachusetts State Building Code, and the Massachusetts Electrical Code.
- B. Utilized battery packs mounted integral with fluorescent fixtures shall energize upon failure of normal power and shall provide approximately the constant light output delivered under normal power operation, for a period not less than 90 minutes. The unit shall contain a transistorized inverter ballast, a transfer relay and associated circuitry, a battery charger and batteries of nickel-cadmium. In addition, a test button and derangements signal light shall be provided to monitor the charging function.
- C. Battery packs mounted remote from luminaires: Conform to the applicable requirements of UL 924. The battery-powered source shall provide continuous power to lighting loads, consisting of any mix of HID, fluorescent, or incandescent lamps. During short power interruptions, brownout conditions or a total lapse of normal AC power, it shall supply the full rated load at both 120 and 277 volts for ninety minutes to a minimum voltage level of 87-1/2% of nominal voltage.

## 2.5 LIGHTING CONTROL EQUIPMENT

- A. General Requirements. Provide lighting control components suitable for the lighting system specified and compatible for interface with other associated control devices. Lighting control components shall be rated for continuous service and operate satisfactorily in every respect while the branch circuit power supply voltage to each system is within a 105 to 130 volt range at 60 hertz. Electrical contacts shall have precious metal surfaces.
- B. Lighting Contactors
  - 1. Conform to the applicable requirements of UL 508.
  - 2. Contactors shall be two pole mechanically held, electrically operated lighting contactors enclosed in a NEMA 1 enclosure. The contactor shall be supplied with a "hand-off-auto" selector switch, a fused control circuit, a two-pole relay which will allow the use of one pole photoelectric and time clock controls. The contactor shall be supplied with coil clearing contacts which will de-energize the coils if the control device is non-momentary. The contactors shall have current ratings as called for on the drawings.
  - 3. The photo control shall have a turn on range of from .5 to 2.5 footcandles with a turn off level between 1 and 5 footcandles (minimum) higher. A time delay feature shall be incorporated as a part of the control circuit to prevent turn offs by stray transient light.
  - 4. Acceptable for operations at 120V nominal, single-phased transient 60HZ.
  - 5. Rated for pilot control circuit operation, 10A at 120 VAC.
- C. Lighting Relays
  - 1. Conform to the applicable requirement of UL 508.
  - 2. Electrically operated and mechanically held.
  - 3. Rated at 600 volts, 60 hertz, 25 amperes with number of poles and enclosure as indicated.
- D. Time Switches
  - 1. Conform to the applicable requirements of UL 887.
  - 2. Pre-wired with astronomic dial, 36-hour synchronous reserve power motor.
  - 3. Manual on-auto-off bypass switches for up to three individual circuits.
  - 4. Rated at 240 volts (minimum), 60 hertz, 40 amperes continuous duty with number of poles, throws and enclosure as rated.
- E. Photoelectric Sensor
  - 1. Conform to the applicable requirements of UL 773.
  - 2. Operation in temperature range of minus 50°C to plus 60°C.
  - 3. Dusk to dawn operation with adjustments from two to 50 foot candles with a five-second time delay to preclude false switching.
  - 4. Weatherproof and tamperproof.
  - 5. Acceptable for operation from a supply voltage range of 105 to 285 volts AC.
  - 6. Rated for a lamp load of 1000 watts of incandescent lighting; 1800 va of mercury vapor, fluorescent, or high-pressure sodium lighting.
  - 7. Minimum life at rated load: 8000 on-off operations.
  - 8. Provided with three blade, twist lock polarized plug and receptacle.
  - 9. Photoelectric sensors shall be mounted facing a northerly direction.
  - 10. 1Photoelectric sensors, upon failure, shall default to the "on lighting" position.

F. Light Intensity Controls

1. Enclosed, automatic or manually, continuously-adjustable, and completely solid state for the control voltage and rated load indicated.
2. Incandescent systems.
3. Fluorescent systems.
4. HID systems.

G. Wall Switches

1. Fed. Spec. W-S-896, types II and III. Switches installed in hazardous areas: Explosion-proof type in accordance with the NEC and as indicated.
2. Switches: Single unit, toggle, butt contact, quiet type with an integral mounting strap.
3. Wall switches for remote control: Momentary contact type suitable for mounting in a single gang outlet box space and compatible with standard design wall plates.
4. Switch Ratings
  - a. For 120 volt circuits: 20 amperes at 120 volts AC.
5. Switches shall be connected to the wiring with screw clamp type terminals.
6. Wall Plates
  - a. Type 304 stainless steel
  - b. Standard designs so the products of different manufacturers will be interchangeable.
  - c. Where switches are mounted adjacent to each other, the plates shall be common for each of the groups of switches.
7. Incorporate barriers between switches within multigang outlet boxes where required by the NEC.

H. Controls

1. The controls will allow automatic control of the lighting system and will provide on-off control of the lighting in response to two modes of operation.
  - a. Manual
  - b. Automatic

In the automatic mode, the primary control device shall be the photocell. However, the time clock will be wired into the control circuit such that the light may be turned off for a preset period of time during the normal photocell "on period." This time clock controlled "off" period shall be completely programmable for periods of time as short as 15 minutes and the settings shall be visible on the face of the time clock. The time clock shall be electrical mechanical type with adjustable trip dogs. Astronomical electronic time switch shall not be used.

I. Key Switch

1. The key switch shall be a heavy duty oil tight 3 position selector switch rated 10 amperes at 120 VAC.



## **PART 3 - EXECUTION**

### **3.1 LIGHTING FIXTURES**

- A. Install lighting fixtures in accordance with the manufacturer's instructions, complete with lamps, hangers, brackets, poles, fittings, and accessories, ready for operation as indicated. Align, mount and level the lighting fixtures uniformly.
- B. Avoid interference with and provide clearance for equipment. Where the indicated locations for the lighting fixtures conflict with the locations for equipment, change the locations for the lighting fixtures by the minimum distances necessary as approved by the Engineer. There are some locations where installation of poles, luminaires, and conduit system will cause interference with Rail Right of Way and Rail facilities. In these instances, the Contractor shall call attention to the fact that, these interferences will take place and will work with Rail Operator and the Engineer to assure corrections are made so as not to delay the construction schedule.
- C. For suspended lighting fixtures, the mounting heights shall provide the clearances between the bottoms of the fixtures and the finished floors as indicated. Chains shall not be used for suspension of fixtures.
- D. Lighting fixture supports shall provide support for all the fixtures. Anchor supports to the structural slab or to structural members as indicated. Supports shall maintain the fixture positions after cleaning and relamping.
- E. Surface mounted lighting fixtures shall be bracketed rigidly from the mounting surfaces. Provide a 1/4-inch clearance between surfaces when the fixture is flat mounted against concrete surfaces. Nipples carrying wire between fixtures shall be watertight.
- F. Exterior fixtures mounted on block or brick walls shall be supporting anchor devices of the expansive lead type. No power driven anchors will be acceptable.
- G. Where aluminum is placed in contact with dissimilar materials, except galvanized steel, zinc or stainless steel, treat contact surfaces as follows:
  - 1. When in contact with dissimilar metals, apply a prime coat of zinc chromate primer followed by two coats of aluminum and masonry paint.
  - 2. When in contact with concrete, masonry and plaster, apply to aluminum contact surfaces zinc chromate primer, bituminous paint, aluminum metal and masonry paint or pressure tape.
  - 3. When in contact with wood or other absorptive materials, apply two coats of aluminum house paint to such materials and protect aluminum contact surfaces with bituminous paint.
- H. Provide pendant fixtures with swivel hangers to assure a plumb installation and have a minimum 25° swing from horizontal in all directions. Single unit suspended fluorescent fixtures shall have twin stem hangers. Multiple unit or continuous units shall have a tubing or stem for wiring at one point and tubing provided for each unit length of chassis including one at each end. Tubing shall not be less than 3/16 inch in diameter. Motion of swivels or hinged joints shall not cause sharp bends in conductors or damage to insulation. For heavy pendant mounted fixtures, where support independent of box is required and where conduit and outlet boxes are installed on surface, provide safety swivel hangers with fixture studs.

- I. Install fixtures to be pole mounted in accordance with the manufacturer's recommended installation practices as indicated.
- J. Provide required lamps in each lighting fixture as soon as fixtures are properly installed.
- K. Light meter readings shall be taken at night to insure proper aiming of the fixtures. The Contractor shall provide men and equipment to make any required field adjustments at this time. The Engineer shall have the right to witness illumination measurements. See Contract Drawings.

### **3.2 BALLASTS**

- A. Install ballasts, other than those mounted integrally within luminaires, as indicated, and in such a manner that the ballast is protected from weather, moisture, and other atmospheric conditions, and in such a manner that ambient temperature surrounding the ballast will not cause the temperature of the ballast housing hot spot to exceed UL requirements. Voltage drop to lamp, due to remote mounting shall not exceed one percent of the nominal lamp voltage. Secondary ballast conductors for high pressure sodium lamps shall have 1000-volt, high temperature insulation.

### **3.3 LIGHT POLES**

- A. Install light poles in accordance with the manufacturer's recommended installation practices as indicated.

### **3.4 CONCRETE BASES**

- A. Obtain necessary templates and anchor kits before starting work. Construct bases in accordance with details shown on the plans.

### **3.5 AUXILIARY LIGHTING EQUIPMENT**

- A. Install as indicated and in accordance with manufacturer's instructions.
- B. Anchor firmly in place.
- C. Test and adjust for proper operation in accordance with the manufacturer's instructions.

### **3.6 LIGHTING CONTROL DEVICES**

- A. Install lighting control devices in accordance with the manufacturer's recommended installation practices, and as indicated.
- B. Where indicated, incorporate the components in panelboards behind separate doors and mount them on sound absorbing materials.
- C. Install circuit breaker or fuse protection for the control circuits.
- D. Mount the switches on the strike plate side of the doors.

- E. The existing lighting panel is mounted inside the Electrical Equipment Building. Install new circuit breakers in existing panel. Modify existing panel to accommodate new circuit breakers.
- F. The contactor and control relay shall be incorporated into one NEMA 1 enclosure mounted inside the Electrical Equipment Building.
- G. All control components shall be neatly labeled or stenciled as to the identification and purpose of the component (i.e., "Contactor C1," "Time Switch TS1," "Key Switch KS1", etc.).
- H. The Contractor shall initially set the time clock so that its control position is closed from 5:00 P.M. through 1:00 A.M. and opened 1:00 A.M. through 4:00 A.M.
- I. As-built copy of the component arrangements and wiring of the lighting controls shall be placed in a plastic envelope inside the lighting panelboard. A copy shall be included in the as-built record for the project.
- J. The photoelectric controls shall be mounted on the rear outside wall of the Electric Equipment Building. The photo control wiring shall be minimum No. 10 AWG. The photo control shall provide pilot control for the lighting contactors and shall not have any direct connections to any luminaires.

### **3.7 FIELD QUALITY CONTROL AND INSPECTION**

- A. Inspect luminaires, lamps and associated hardware prior to and after installation to confirm that they are of the quality and type as specified herein and as indicated, and are free of defects and damage.
- B. Provide luminaires and lighting equipment to the project site complete, with suspension accessories, canopies, hickey, castings, sockets, holders, reflectors, ballasts, diffusing materials, louvers, frames, recessing boxes, and related items, completely wired and assembled as indicated.
- C. Whenever practicable, test lighting systems at the same time that the distribution panelboard or switchboard is tested.
- D. Adjust floodlights in accordance with the aiming chart provided by the manufacturer. Make adjustments during darkness to obtain the optimum lighting levels throughout.
- E. After satisfactory completion of the specified installation, the illumination system shall be placed in operation. Final acceptance will not be made until the system has operated satisfactorily for a period of not less than 30 days from a date designated by the Engineer. This test period shall be included within the specified contract time. Operation of the system shall not in any way be construed as an acceptance of the system or any part of it or as a waiver of any of the provisions of this contract. The Contractor shall be responsible for the system during this period of operation and he shall make any adjustments or repairs which may be required and remedy defects or damages which may occur, at his own expense. The Contractor will not be required to pay for electrical energy consumed by the system during this trial operation.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 GENERAL**

- A. Separate measurement and payment will not be made for work under this section, but all costs in connection therefore, for furnishing and installing lighting systems along the BRT Stations, the Silver Line Busway, and the Shared Use Path, including luminaires, mounting hardware, conduits, wires, handholes, light poles, and all other incidentals necessary to complete the item, including coordination with the applicable electric company, shall be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Station, and the Contract Lump Sum Price for Item No. 820.10 – Highway Lighting - Roadway.

**END OF SECTION**

## **SECTION 16700**

### **POWER WIRE AND CABLE**

#### **PART 1 - GENERAL**

##### **1.01 DESCRIPTION**

- A. This Section specifies furnishing and installing power wire and cable for the AC power distribution system of the Talbot Avenue Commuter Rail Station and the Talbot Avenue and Woodrow Avenue Bridge replacements.

##### **1.02 QUALITY ASSURANCE**

- A. Material and workmanship shall be of the highest quality assuring durability for minimum life expectancy of 40 years. These cables shall be suitable for use in the environment to be encountered on a railroad system, and underground distribution system. The cables shall also be certified for continuous operation at 90 degrees C in wet or dry locations with no conductor failing in continuity or with loss of insulation to cross or ground less than one (1) meg-ohm.
- B. Qualification
  - 1. All wire and cable manufacturers must be approved by the Engineer. The Contractor shall provide all data required for the Engineer's evaluation and shall make the arrangements for any required demonstrations and tests.
  - 2. Qualifications shall be based on the following criteria:
    - a. Past Performance and Experience. The cable manufacturer(s) must demonstrate previous successful experience in supplying cable to the railroad industry for use as AC power cables. A list of such installations shall be provided for each cable manufacturer to be considered.
    - b. Quality Assurance Program. The manufacturer(s) of cables, in accordance with the requirements of these Specifications, shall be accomplished in compliance with a Quality Assurance Program that meets the intent of the ASQC Standard CI-1968, General Requirements for a Quality Program. Such compliance shall promote a thoroughly tested cable, which will render long service life to the user. Prime concern must be focused on the necessary formal assurance requirements to insure that cable failure cannot be attributed to actions or lack of actions by the manufacturer.
    - c. Technical Data. The Contractor shall provide full technical data, which demonstrates compliance with the requirements of these Specifications for each specified cable type the Contractor plans to supply.
    - d. Demonstration Tests. The Contractor shall make arrangements with the prospective cable manufacturer(s) to perform demonstration tests as required by the Engineer.

- e. Sample Specimens. The Contractor shall, if requested by the Authority, furnish to the Engineer within 20 days after the Notice-to-Proceed, sample specimens in four (4) foot lengths similar to that which the manufacturer(s) proposes to furnish for each type cable specified herein. The sample specimens shall remain the property of the Authority.
- f. The manufacturer(s) shall certify that he shall comply with the following warranty prior to selection:
  - 1. The manufacturer(s) warrants that the design, material, and workmanship incorporated in each item of cable shall be of the highest grade and consistent with the established, and generally accepted, standards for aerial and underground cable for ac power circuits; and that each such item and every part and component thereof shall comply with these Specifications.
  - 2. The manufacturer(s) agrees that this warranty shall commence with the acceptance of each item of the cable, whether the defect be patent or latent, and shall continue for a period of two (2) years after initial satisfactory operation of the item or four (4) years after acceptance of the item, whichever is shorter.
  - 3. The warranty covering any length of cable that shall be replaced by the manufacturer(s) under the above conditions shall be reinstated for a period of two (2) years effective as of the day when said replacement is affected. If the failure is found to be of major importance and affects any other item of cable, the reinstatement of the warranty shall then be extended to cover the item so affected as well, and shall start as of the date of such replacement. The warranty reinstatement provided for in this subparagraph 3 shall apply only to the first replacement or repair of any such item and, in the case of failure of major importance, to the first extension of the said warranty to said affected items.
  - 4. The foregoing warranties are exclusive and in lieu of all other warranties written, oral, implied, or statutory (except as to title and freedom from lien). In no event shall the manufacturer be liable by reason of breach of warranty for special or consequential damages.

C. After Selection

- 1. The Contractor shall monitor the manufacturer(s) of the wire and cable to assure that the approved Quality Assurance Program is being closely adhered to and that the wire and cable is being manufactured in accordance with these Specifications and the approved submittals.
- 2. Each finished wire and cable shall be traceable to the test date on file for each step in its manufacturing process.
- 3. Inspection

- a. The Authority, or its authorized representative, shall have the right to make such inspection and tests as necessary to determine if the cable meets the requirements of these Specifications. The Authority shall have the right to reject cable, which is defective in any respect.
- b. The Authority shall be given ten (10) days advance notice of the date the cable will be ready for final testing so that the Authority may witness the tests, if it so elects.
- c. Physical tests shall be made on samples selected at random at the place of production. Each test sample shall be taken from the accessible end of different reels. Each reel selected and the corresponding sample shall be identified. The number and lengths of samples shall be as specified under the individual tests. All applicable tests for the cable materials and cable construction specified shall be performed.
- d. The manufacturer(s) shall provide, at the point of production, apparatus and labor for making any or all of the following tests under the supervision of the Authority's Inspector or Engineer; to include:
  - 1. Conductor size and physical characteristics.
  - 2. Insulation HV and IR tests.
  - 3. Physical Dimension Tests.
  - 4. Special tests on materials in coverings.
  - 5. Final HV, IR, and conductor resistance tests on shipping reels.
- e. Certified electrical and physical test reports shall be furnished for the finished cables no later than the time of shipment. Each test document shall, in addition to the test results, indicate the date the tests were performed and the signature of the manufacturer's authorized representative.
- f. The Authority reserves the right to conduct itself, or by its duly authorized representative, those tests it so elects to further satisfy itself that the cable is manufactured in accordance with the requirements of these Specifications.

### **1.03 SUBMITTALS**

- A. The Contractor shall submit the following to the Engineer for approval:
  - 1. Each cable manufacturer's Quality Assurance Program.
  - 2. Full technical data for each type of cable which each cable manufacturer intends to supply.
- B. The Contractor shall submit two (2) certified copies of the following to the Engineer for approval.

1. Cable test reports for all demonstration tests required by the Engineer.
  2. Cable test and inspection reports for tests and inspections required and described by these Specifications.
  3. Test reports of cable tests conducted in the field in accordance with approved testing procedures.
  4. Certification that each cable supplied complies with the requirements of these Specifications.
- C. Information to be supplied by certified cable test reports shall include the following:
1. Report number.
  2. Date and location of test.
  3. Description of test and test conditions.
  4. Complete cable or wire description.
  5. Lot, batch, or reel identification number.
  6. Quantitative test results.
  7. Summary of the test results.
  8. Information on the components of the cable tested to include batch numbers and physical and electrical properties.
- D. The Contractor shall furnish to the Authority five (5) copies of the cable manufacturer's instructions and procedures for potheading of each type underground cable to be furnished.

#### **1.04 DELIVERY, STORAGE AND HANDLING**

- A. Packing
1. Products shall be so assembled or packed as to permit convenient handling and to protect against loss or damage during shipment.
  2. Wire smaller than No. 4 AWG shall be shipped in cartons or in coils. When shipped in coils, the wire shall be securely bound with a layer of waterproof paper with each turn overlapping the other one-half its width if flat-edge paper is used, or one-third its width if folded-edge paper is used. Wires larger than No. 4 AWG shall be shipped on nonreturnable reels protected by fiberboard covering, bound with a steel strap or wire to prevent damage in transportation.



**B. Marking**

1. Purchaser's order, requisition and package number, name of Consignor, and name and address of Consignee, shall be plainly marked on outside of cartons, coils or reels.
2. Detail list of cartons, coils or reels shall be furnished for each shipment. Where carload shipments are made, routing and car identification shall be shown.

**C. Handling**

1. Each shipment shall be inspected by the Contractor for evidence of damage upon delivery. Any damage such as reels loose from their blockings, damaged protective wrapping or lagging, or broken flanges shall be reported to the manufacturer, the carrier, and the Authority. The Authority reserves the right to reject any cable damaged during the shipment, storage or handling process.
2. Cable reels shall be lifted with a lifting sling and spreader attached to a shaft through the wheel hubs, or with a forklift with tines supporting both reel heads. Lift pressure shall not, at any time, be placed on the cable.
3. Reels shall be rolled only on flat surfaces cleared from any debris. Direction of rolling shall tighten the cable wind marked on the reel.
4. The factory-applied protective wrapping shall be left in place until cable installation. After partial installation of any cable from a reel, the remaining cable shall be resealed and the end tied off.

**D. Storage**

1. Cable reels shall be stored on a firm paved surface or on cribbing with good drainage. Outdoor storage time shall not exceed the manufacturer's recommendations.
2. Suitable means, such as protective barriers, shall be provided to protect the cables from accidental damage during storage.
3. Security against theft and vandal damage shall be provided by the Contractor at no additional cost to the Authority.

## **PART 2 - PRODUCTS**

### **2.01 AC POWER DISTRIBUTION CABLES**

**A. Low Voltage Power Cables (less than 1000 volts)**

1. Low voltage power cables less than 1000 volts shall be Type RHH, RHW or USE, intended for use as direct burial, in raceways or aerial applications. Conductors shall be stranded copper per ASTM B-3 or B-8. Insulation shall be cross-linked polyethylene in accordance with NEMA WC 7/ICEA S-66-524.

2. High voltage power cables (both insulated and aerial) shall be installed, provided and terminated by NSTAR.

## **2.02 CABLE FIREPROOFING TAPE**

- A. Power cables entering manholes shall be fireproofed in accordance with MBTA Standard Specifications P-127, a copy of which can be found in Technical Appendix TA4.

## **2.03 CABLE TERMINATIONS**

- A. AC power cable terminations shall be in accordance with MBTA Standard Specifications Section 16050, Article 2.14.

## **2.04 IDENTIFICATION TAGS**

- A. Identification tags for power and control wires shall be in accordance with MBTA Standard Specifications Section 16050, Article 2.14.

## **2.05 CABLE IDENTIFICATION**

- A. Conductors shall be marked indicating the manufacturer's name, conductor size, conductor material, insulation type, voltage rating and year of manufacture repeated every two feet on the outside of the cable jacket.

# **PART 3 - EXECUTION**

## **3.01 GENERAL**

- A. The installation of power wire and cable shall conform to applicable sections of the NEC and the requirements as specified herein.
- B. The Contractor shall give the Engineer 24 hours notice prior to installing cables.
- C. In certain types of installation where the cable cannot be constrained, ample cable slack shall be provided for additional flexibility due to vibration of such equipment.
- D. Cables shall not be bent to a radius less than eight (8) times the diameter of the cable during installation or as finally installed.
- E. All cables shall be tagged at their termination points. In addition, all cables shall be tagged within handholes, manholes, enclosures, etc. and on each side of any barrier the cable passes through. Cables shall also be tagged at aerial exits from conduit risers.
- F. All cable entrance openings shall be sealed with either a compression type fitting or pliable sealing compound after the cable is in place. Sealing compound shall be used to seal the area around cable where the cable emerges from the end of a conduit or pipe. All spare conduits shall be sealed or plugged in an approved manner.

- G. Where cables leave conduits, the ends of the conduit shall be fitted with approved fittings for the conduit system.
- H. Wherever multiple conductor cables are terminated, the outer sheath of the cable shall be carefully removed to the point of cable entrance. At the end of the cable sheath or covering, two (2) layers of plastic electrical tape shall be applied.
- I. Contractor shall arrange the cables to allow free access to all existing cables for maintenance.
- J. Cable terminations and splices shall be made in strict accordance with Authority's standards. Terminations and splice fittings for all underground conductors shall be tool applied compression connectors of material and design compatible with the conductors for which they are used. All spliced ends of cables will utilize a "Raychem" or equivalent watertight seal covering, over the compression lug. This watertight seal covering will have an insulation rating equivalent to the conductor for which it is being used.

### **3.02 INSTALLATION IN CONDUIT**

- A. Reels shall be stripped of all nails in outside edges of reel heads before pulling of cable, and shall be conveniently located for feeding cable into the conduit without excessive bending or possible injury to cable by abrasion on the sides of manholes or handholes. Reels shall be jacked to clear ground level by at least six (6) inches before pulling of cable.
- B. Cable reels shall be carefully handled to avoid injury to persons or cables. Movement of reels on loading skids or sloping grades shall be controlled by use of a snub line or wedge. Reels shall always be blocked after positioning.
- C. Cable shall be pulled into conduits with the use of a pulling eye approved by the Engineer. Pulling ropes shall be attached to the pulling eye with ball-bearing swivels to prevent twisting of cable during pulling.
- D. Cable shall be pulled into conduits under moderate tension. Manufacturer's recommended maximum pulling tension shall not be exceeded at any time. Before pulling any cable into conduits, the Contractor shall first consult with the Engineer as to methods and locations of cable pulling.
- E. Personnel shall be stationed between the reel and the conduit entrance during pulling operations to inspect control and direct the passage of cable. The conduit mouth shall be equipped with conduit shields to prevent chafing of the cable.
- F. Cables shall be lubricated with an approved material in accordance with the manufacturer's recommendation which shall be placed onto the cable during the pulling operation.
- G. Cables shall not be allowed to chafe on the ground, handhole edges, or any sharp surfaces during pulling. Flexible cable pulling tubes shall be provided to guide and protect the cable, where necessary.

- H. All cut ends of the cable shall have a watertight seal installed immediately after installation, until the cable is spliced or terminated.
- I. Cables shall be installed with freedom of horizontal movement to accommodate expansion and contraction of the cables in the conduits. Cables passing through handholes shall have at least one (1) bend to accommodate such changes in length.

### 3.03 SPECIAL PROTECTION

- A. The Contractor shall provide appropriate special protection for cables in areas where the cables are unavoidably exposed to hazardous conditions such as vibration or sharp corners on equipment. The Contractor shall be responsible for replacing, at no additional cost to the Authority, any cable he has installed which is subsequently damaged prior to acceptance as a result of his failure to provide such special protection.

### 3.04 TESTING

#### A. General

- 1. The Contractor shall provide all instruments, materials and labor required for tests specified herein.
- 2. Tests conducted at the factory shall include, but not be limited to, the following:

- a. Manufacturer's standard tests.
- b. Tests relevant to NEMA WC 7/ICEA S-66-524 standards that are not included in the manufacturer's standard tests. These tests include, but are not limited to, the following:

NEMA	6.4	Test Samples and Specimens for Physical and Aging Tests
NEMA	6.6	Accelerated Water Absorption Tests
NEMA	6.11	Tests for Discharge Resistance
NEMA	6.12	Volume Resistivity
NEMA	6.14	Voltage Tests
NEMA	6.15	Insulation Resistance

- 3. Tests and checkouts in the field shall include, but not be limited to, the following:

Dielectric Test  
Continuity Test  
Insulation Resistance Test  
Phasing Test

- 4. All high voltage cable testing (i.e. primary side) to be completed by respective power company.

B. Conditions for Tests

1. Prior to performing any cable testing, the following conditions shall be fulfilled by the Contractor:
  - a. Contractor shall have submitted cable testing procedures for the Engineer's approval at least 45 days in advance of the testing. No testing shall be performed unless the Contractor has the approved test procedures in hand.
  - b. For factory tests, a minimum of four weeks advance notification shall be given to the Engineer on the schedule date of tests to enable him to witness the tests. Field tests shall be scheduled in consultation with the Engineer.

C. Witness Tests

1. The Engineer, at his option, shall witness complete testing on all cable installation.

D. Field Tests

1. General. All AC power cables shall be subjected to Acceptance Tests as specified below to ascertain that the dielectric strength of the cable insulation has not been impaired during installation, that the splices and termination are properly made and to confirm the integrity of the cable system prior to energization. Tests shall include continuity tests and insulation resistance tests.
  2. Acceptance Tests. After installation of the entire length of a cable, the Contractor shall perform the tests listed below on each cable. To preclude damage to equipment and devices, the tests shall be conducted before the cable is terminated at the electrical equipment. If termination have already been made, cables shall be disconnected from the equipment for testing and shall be reconnected after completion of tests.
    - a. Dielectric Test
      1. This test shall be performed to ensure that the cable insulation has not been impaired during installation.
    - b. Continuity Test
      1. This test shall be performed to prove the continuity of the conductor.
    - c. Insulation Resistance Test
      1. This test shall be performed to determine the cable insulation resistance to ground.
      2. Tests shall be conducted with a motor-driven megger. Test voltage shall be applied between the conductor and ground and

shall be held until the reading reaches a constant value for five minutes. Insulation resistance values obtained by the megger tests shall not be less than two megohms. Contractor shall bring to the attention of the Engineer the results of similar tests having unequal readings with the variations of 25 percent or more.

3. For each test, the Contractor shall record the temperature, humidity, and duration of the test.

3. Defective Cables

- a. Any cable installed under this Contract found defective during the testing shall be replaced with new cables at the expense of the Contractor.

- E. A record of all approved tests shall be forwarded to the Engineer.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.01 GENERAL**

- A. Separate measurement and payment will not be made for work required under the Section, but all costs in connection therefore shall be included in the Contract Lump Sum Price for the items of work to which they pertain.

### **END OF SECTION**

## SECTION 16749

### FIBER OPTIC CABLE SYSTEMS

#### PART I - GENERAL

##### 1.1 DESCRIPTION

- A. This section specifies the requirements for multimode and singlemode, loose tube, fiber optic cable, conduit and ancillary equipment to be furnished and installed in support of communications from EOPSS data facility at 200 Arlington St. to PoE Switches at Chelsea Silver Line Gateway (SLG) stations, and to interconnect PoE switches at these stations; as shown in the Contract Drawings. The ancillary equipment includes fiber optic termination panels, SFP Modules, fiber optic jumpers, racks, connectors, test equipment and incidental materials.
- B. The Contractor's work shall include installation of a singlemode fiber optic communications backbone throughout the length of the SLG system, with terminations located within each of the four communications equipment enclosures at Mystic Mall, Downtown Chelsea, Box District, and Eastern Ave. stations. The communications backbone shall have a ring topology using two separate conduits within the communications duct bank depicted in the electrical plans and specifications. The communications backbone shall consist of 24 strands of single-mode fiber optic cable as specified herein.
- C. An additional fiber optic connection shall be required for the Automated Fare Vending equipment, which must run on physically segregated LAN infrastructure (switches). The AFC LAN shall connect to the MBTA's existing AFC infrastructure by means of a fiber optic cable connection to be provided by the MBCR at the Eastern Ave. station communications enclosure. This connection shall require the contractor to furnish and install a Dense Wavelength Division Multiplexer (DWDM) and de-multiplexor. The contractor shall be required to coordinate and finalize details of AFC LAN connectivity with the MBCR and MBTA.
- D. All singlemode and multimode fiber connections shall be terminated with LC connectors.
- E. Finished cables shall conform to the applicable performance requirements of the Insulated Cable Engineers Association, Inc. (ICEA) *Standard for Outdoor Optical Fiber Cable* (ICEA S-87-640).
- F. At the MBTA's request, the manufacturer(s) shall provide engineering services, installation procedures, and technical support concerning the items contained in this specification.

##### 1.2 RELATED SECTIONS

- A. Section 01010 SUMMARY OF WORK
- B. Section 16050 BASIC MATERIALS AND METHODS FOR ELECTRICAL WORK
- C. Section 16450 GROUNDING
- D. Section 16840 CLOSED CIRCUIT TELEVISION SYSTEM
- E. Section 16876 COMMUNICATIONS GROUNDING OF EQUIPMENT
- F. Section 16898 COMMUNICATIONS SYSTEMS TEST

### **1.3 REFERENCES**

- A. Insulated Cable Engineers Association (ICEA)
- B. National Electric Code (NEC)
- C. Electronic Industries Association (EIA)
- D. Telephone Industries Association (TIA)
- E. Institute of Electrical and Electronics Engineers (IEEE)
- F. Telcordia (formally BellCORE)
- G. International Telecommunications Union (ITU)
- H. Underwriters Laboratory (UL)

### **1.4 SUBMITTALS**

- A. Submit descriptive literature, and manufacturer specification sheets, for all fiber optic cables and equipment proposed for use in accordance with the requirements of this Specification for approval prior to procurement, fabrication, assembly, installation, and testing.
- B. The Contractor shall submit fiber optic cable routing diagrams for approval by the MBTA.

### **1.5 DELIVERY, STORAGE, AND HANDLING**

- A. The Contractor is responsible for the storage, delivery, and handling of all materials provided under this Specification. Items shall be stored in a safe and secure location. All equipment shall be protected from water, dust, etc.
- B. The required length of cable shall be wound on reels. Each reel shall contain only one continuous length of cable. The packaging shall be constructed so as to prevent damage to the cable during shipping and handling.
- C. When the length of an order requires a large (4 feet or greater) reel the cable shall be covered with a three layer laminated protective material. The outer end of the cable shall be securely fastened to the reel head so as to prevent the cable from becoming loose in transit. The inner end of the cable shall project into a slot in the side of the reel, or into a housing on the inner slot of the drum, in such a manner and with sufficient length to make it available for testing.
- D. Test tails shall be at least 2 meters long. The inner end shall be fastened so as to prevent the cable from becoming loose during shipping and installation.
- E. Reel Marking and Labeling: Every cable shall be delivered with the following information:
  - 1. Reel Label:
    - a. Part number
    - b. Reel number
    - c. Length (ft/m)
    - d. Marking (ft/m) top and bottom



- e. Date of Manufacture
  - f. UL/ETL/CSA listing information
  - g. Package ID
  - h. Quantity
  - i. Customer ID
  - j. Package count
  - k. Factory order number
  - l. Release part number
  - m. "Ship to:" Address
  - n. "Attention to:"
2. Stenciling:
- a. Manufacturer's name and address
  - b. Direction of rotation
  - c. Reel Size
  - d. "DO NOT LAY REEL ON SIDE"

## **1.6 QUALITY ASSURANCE**

- A. The cable manufacturer shall be ISO 9001 registered.
- B. All optical fibers in cable lengths of 300 m or greater shall be 100 % attenuation tested. The attenuation shall be measured at 850 nm and 1300 nm for multimode fibers. The attenuation shall be measured at 1310 nm and 1550 nm for single-mode fibers. The manufacturer shall store these values for a minimum of 5 years. These values shall be available upon request.

## **1.7 WARRANTY**

- A. See Specification Section 01010

# **PART 2 – PRODUCTS**

## **2.1 MATERIALS**

- A. All material shall be new and unused, and the workmanship shall be in accordance with the highest standards of the electronic equipment industry. Material discontinued by the manufacturer shall not be accepted. All components shall be UL or ETL listed.
- B. Material purchased under this Section shall be covered by standards illustrated in paragraph 1.03, and the manufacturer's warranties against material and workmanship.
- C. Provide all material capable of operating within a transit system environment, subject to temperature, humidity, vibration, and light conditions typically encountered.

## **2.2 FIBER OPTIC STRANDS**

- A. All fibers in the cable shall be usable and meet required specifications.

- B. Each optical fiber shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.
- C. Each optical fiber shall consist of a doped silica core surrounded by a concentric glass cladding. The fiber shall be a matched clad design, manufactured utilizing Outside Vapor Deposition.
- D. Each optical fiber shall be proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7 GN/m<sup>2</sup>).
- E. The fibers shall be coated with a dual layer acrylate protective coating. The coating shall be in physical contact with the cladding surface.
- F. The attenuation specification shall be a maximum value for each cabled fiber at  $23^{\circ} \pm 5^{\circ}\text{C}$  on the original shipping reel.

### 2.3 SINGLE-MODE (DISPERSION UN-SHIFTED) WITH LOW WATER PEAK

- A. Central tube cable, 12-Strand Fiber, OS2 OSP, Loose Tube, Outdoor Rated with UV Resistant black jacket, fully waterblocked with gel-filled buffer tube, no rods – crush impact and abrasion resistant.
- B. The single-mode Low Water Peak fiber utilized in the optical fiber cable shall meet EIA/TIA- 492CAAB, "Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak," and ITU recommendation G.652.C, "Characteristics of a single-mode optical fiber cable."
- C. Cladding Diameter:  $125.0 \pm 0.7 \mu\text{m}$
- D. Core-to-Cladding Concentricity:  $\pm 0.5 \mu\text{m}$
- E. Cladding Non-Circularity:  $\pm 1.0 \%$
- F. Mode Field Diameter:  $9.2 \pm 0.4 \mu\text{m}$  at 1310 nm;  $10.4 \pm 0.5 \mu\text{m}$  at 1550 nm
- G. Coating Diameter:  $245 \pm 5 \mu\text{m}$
- H. Attenuation:  $\pm 0.4 \text{ dB/km}$  at 1310 nm and  $\pm 0.3 \text{ dB/km}$  at 1550 nm.
- I. Attenuation Uniformity: No point discontinuity greater than 0.05 dB at either 1310 nm or 1550 nm.
- J. Attenuation at the Water Peak:  $\pm 0.4 \text{ dB/km}$  at  $1383 \pm 3 \text{ nm}$ .
- K. Cabled Cutoff Wavelength ( $\lambda_{\text{ccf}}$ ):  $< 1260 \text{ nm}$ .
- L. IEEE 802.3 GbE Performance: The fiber shall support laser-based Gigabit Ethernet (GbE) operation in the 1000BASE-LX (1300 nm) up to 5000m.
- M. Macrobend Attenuation: The attenuation due to 1 turn of fiber around a  $32 \pm 2 \text{ mm}$  diameter mandrel shall not exceed 0.05 dB at 1550 nm. The attenuation due to 100 turns of fiber around a  $60 \pm 2 \text{ mm}$  diameter mandrel shall not exceed 0.05 dB at 1550 nm.
- N. Zero Dispersion Wavelength ( $\lambda_0$ ):  $1302 \text{ nm} \pm 10 \text{ nm}$
- O. Zero Dispersion Slope ( $S_0$ ):  $\pm 0.092 \text{ ps}/(\text{nm}^2 \bullet \text{km})$
- P. Dispersion:  $\pm 3.5 \text{ ps}/(\text{nm} \bullet \text{km})$  from 1285 - 1330 nm;  $\pm 18 \text{ ps}/(\text{nm} \bullet \text{km})$  at 1550 nm.
- Q. Fiber Curl:  $> 4.0 \text{ m}$  radius of curvature
- R. Cabled Fiber Polarization Mode Dispersion (PMD):  $\pm 0.5 \text{ ps}/\sqrt{\text{km}}$

S. Max installation load = 600lbs.

## **2.4 MULTI-MODE FIBER**

- A. Central tube cable, 2-Strand Fiber, OM3 OSP, Loose Tube, Outdoor Rated with UV Resistant black jacket, fully waterblocked with gel-filled buffer tube, no rods – crush impact and abrasion resistant.
- B. The multi-mode fiber utilized in the optical fiber cable shall meet or exceed EIA/TIA-568-B.3.
- C. Cladding Diameter:  $125.0 \pm 0.7 \mu\text{m}$
- D. Attenuation: :: 2.9 dB/km at 850 nm and :: 0.9 dB/km at 1300 nm.
- E. Attenuation Uniformity: No point discontinuity greater than 0.05 dB at either 850 nm or 1300 nm.
- F. IEEE 802.3 GbE Performance: The fiber shall support laser-based Gigabit Ethernet (GbE) operation in the 1000BASE-LX (1300 nm) up to 600m.
- G. Max installation load = 600lbs.

## **2.5 CABLE CONSTRUCTION**

- A. Temperature Range. The storage temperature range for the cable on the original shipping reel shall be  $-40^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ . The installation temperature range for the cable shall be  $-10^{\circ}\text{C}$  to  $+60^{\circ}\text{C}$ . The operating temperature range for the cable shall be  $-40^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ . Testing shall be in accordance with FOTP-3.
- B. Tensile Loading and Fiber Strain. When tested in accordance with FOTP-33, "Fiber Optic Cable Tensile Loading and Bending Test," and FOTP-38, "Measurement of Fiber Strain in Cables Under Tensile Load," a length of cable shall be tested to the rated tensile load. The rated tensile load shall be 2670 N (600 lbf). While under the rated tensile load, the fiber shall not experience a measured fiber strain greater than 60% of the fiber proof test level. After being held at the residual load (30% of the rated tensile load) the fiber shall not experience a measured fiber strain greater than 20% of the fiber proof test level nor an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode). After the tensile load is removed, the fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode).
- C. Compressive Loading Test. When tested in accordance with FOTP-41, "Compressive Loading Resistance of Fiber Optic Cables," the cable shall withstand a minimum compressive load of 220 N/cm (125 lbf/in) applied uniformly over the length of the sample. The 220 N/cm (125 lbf/in) load shall be applied at a rate of 2.5 mm (0.1 in) per minute. The load shall be maintained for a period of 1 minute. The load shall then be decreased to 110 N/cm (63 lbf/in). Alternatively, it is acceptable to remove the 220 N/cm (125 lbf/in) load entirely and apply the 110 N/cm (63 lbf/in) load within five minutes at a rate of 2.5 mm (0.1 in) per minute. The 110 N/cm (63 lbf/in) load shall be maintained for a period of 10 minutes. Attenuation measurements shall be performed before release of the 110 N/cm (63 lbf/in) load. The change in attenuation shall not exceed 0.40 dB at 1550 nm for single-mode fibers and 0.60 dB at 1300 nm for multimode fiber.
- D. Cyclic Flexing. When tested in accordance with FOTP-104, "Fiber Optic Cable Cyclic Flexing Test," the cable shall withstand 25 mechanical flexing cycles at a rate of  $30 \pm 1$

- cycles per minute. The fiber shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode). No cracks, splits, tears or other opening shall be present on the inner or outer surface of the jacket. No visible cracks greater than 5 mm in the armor, if present, shall be present.
- E. Twist Test. When tested in accordance with FOTP-85, "Fiber Optic Cable Twist Test," a length of cable no greater than 2 meters shall withstand 10 cycles of mechanical twisting. The fiber shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode). No cracks or splits in the jacket shall be present when inspected under 5X magnification.
  - F. High and Low Temperature Bend. When tested in accordance with FOTP-37, "Fiber Optic Cable Bend Test, Low and High Temperature," the cable shall withstand four full turns around a mandrel at test temperatures of -10 °C and +60 °C. The fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode).
  - G. Impact Resistance. When tested in accordance with FOTP-25, "Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies," the cable shall withstand a minimum of 2 impact cycles at 3 locations separated by at least 150 mm. The impact energy shall be 4.4 N•m. The fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode). The presence of visible cracks, splits, tears, or other openings on the outer surface of the jacket constitute a failure.
  - H. Temperature Cycling. When tested in accordance with FOTP-3, "Procedure to Measure Temperature Cycling Effects on Optical Fiber, Optical Cable, and Other Passive Fiber Optic Components," the change in attenuation after 2 cycles at extreme operational temperatures (-40 °C to +70 °C) shall not exceed 0.40 dB/km at 1550 nm (single-mode) or 0.60 dB/km at 1300 nm (multimode). The change in attenuation is measured with respect to the baseline values measured at room temperature before temperature cycling after the last low and last high temperature.
  - I. Water Penetration. When tested in accordance with FOTP-82, "Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable", a one-meter length of unaged cable shall withstand a one- meter static head or equivalent continuous pressure of water for one hour without leakage through the open cable end.
  - J. Cold Impact Test. When tested in accordance with FOTP-25, "Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies," the cable shall withstand a minimum of 2 impact cycles at 3 locations separated by at least 150 mm. The impact energy shall be 2.9 N•m. The cable shall be conditioned for at least 4 hours at the minimum installation temperature (-10 °C). The presence of visible cracks on either the inner or outer surface of the jacket constitutes a failure. No optical measurements are required.

## **2.6 CONNECTOR HOUSINGS, RACK-MOUNTABLE 1U (PATCH PANELS)**

- A. The Connector Housings shall be a rack mountable combination connector and splice housing. The unit provides for pigtail splicing to the connector panel within a single housing. The 1U- sized unit shall be sized to accommodate the fiber optic cable to be provided and installed. Furnish and install a total of 24 optical fiber patching connection points in each 1U-sized Rack Mountable Connector Housing.

- B. Housings shall be rack mountable in an EIA-310 compatible 19-inch rack. Housings shall be in a 1-rack unit size. One EIA rack space or panel height (denoted as 1U) is defined as being 44.45 mm (1.75 in.) in height.
- C. The unit shall be modular with a splicing compartment and a termination compartment in a single housing.
- D. The unit shall not exceed a depth requirement of 40.6 cm.
- E. The unit shall meet the design requirements of ANSI/TIA/EIA-568 and the plastics flammability requirements of UL 94 V-0.
- F. The unit housings shall be manufactured using 16-gauge steel for structural integrity and shall be finished with a 2-Tone Gunmetal Grey and/or anodized silver for durability. Installation fasteners shall be included.
- G. The unit shall include a clamshell-type cable clamping mechanism to provide cable strain relief. The cable clamp shall accept one cable from 9.5 to 28.6 mm (.37"-1.12") in diameter. The cable clamp mechanism shall also handle multiple smaller fiber count cables when used with the multiple cable insert. The total cable capacity per clamp shall be five cables (:: 10.2 mm (.4") OD) when used with the multiple cable insert. Housing cable clamp capacity shall be two clamps. Additional cable clamps shall be available as an accessory kit.
- H. The front doors shall be made from tinted polycarbonate. Front and rear doors shall utilize a single slide latch to provide ready access and closing. An opening shall be provided in the front and rear doors so that an optional key lock kit can be used. The opening shall be filled with a removable plastic insert so that dust may not enter if the optional lock kit is not used.
- I. There shall be a removable retaining bracket to prevent the door from unintentionally sliding off the hinges.
- J. The housings shall have a labeling scheme that complies with ANSI/TIA/EIA-606.
- K. Provisions for mounting fiber fan-out devices shall be incorporated into the housing. Fiber fan-out devices are used to build 250  $\mu$ m fiber in buffer tubes out to 900  $\mu$ m for fiber protection, and to allow connectorization.
- L. Provide and install 1U – Rack Mountable Connector Housings at the locations and in the equipment racks identified on the Contract Drawings.
- M. The 1U – Rack Mountable Connector Housing shall be similar to Corning Cable System PCH- 01U with the PC1-SPLC splice tray bracket. Include strain relief brackets, cable clamps, splice trays, and two (2) 12-position fiber optic connector panels (for a total of 24 fiber termination points of the connector-type and fiber-type identified elsewhere in this Specification.)

## **2.7 FIBER OPTIC PIGTAIL MODULES**

- A. Fiber optic pigtail shall be comprised of a single single-mode fiber strand compliant with TIA/EIA-568-B-3.
- B. The Pigtail Modules shall have twelve (12) factory installed ST type connectors.
- C. The Pigtail Modules shall contain twelve (12) 8/125  $\mu$ m fibers with a 900  $\mu$ m protective coating that are enclosed by a PVC sheath.

- D. The Pigtail Modules should have a pigtail length of 3m.
- E. The pigtail shall have an insertion loss of 0.5 dB maximum and a minimum reflectance of -55 dB when mated with like jumper.
- F. Pigtail Modules should be similar to Corning Cable Systems CCH-RM12-19T-P03RH.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION**

- A. Each equipment manufacturer shall supply recommended installation procedures for all products supplied. Recommended procedures shall also be supplied for fiber optic cable installation to include duct, direct buried, and aerial installations.
- B. Coordinate all fiber optic cable installation plans with the MBTA and Engineer prior to installation.
- C. Each product shall be tested to ensure compliance with this specification.
- D. Fiber optic cable tests shall include optical time domain reflectometer and power loss.
- E. The fiber optic cable shall meet or exceed performance characteristics when tested in accordance with the EIA/TIA-455A and EIA/TIA-526-7, and EIA/TIA-526-14A standards.

### **PART 4 - MEASUREMENT AND PAYMENT**

#### **4.1 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of the Fiber Optic Cable Systems.

### **END OF SECTION**

## **SECTION 16770**

### **PASSENGER STATION VARIABLE MESSAGE SIGNS**

#### **PART 1 - GENERAL**

##### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Requirements of the following Division 16 Sections apply to this Section:
  - 1. Basic Electrical Requirements 16050
  - 2. Public Address System 16881

##### **1.2 GENERAL DESCRIPTION**

- A. This Section specifies furnishing and installation of equipment necessary to form a complete and operational Variable Message Sign system (VMS) at the Chelsea Silver Line Gateway BRT stations. The VMS system shall display information via Light Emitting Diode (LED) scrolling signs located at each station platform as specified herein and as shown on Contract Drawings.
- B. The VMS shall be controlled from the Public Address (PA) Control System utilizing the MBTA WAN backbone from the existing AIM<sup>®</sup> PA/VMS system installed by ARINC at 45 High St. under a separate contract. The VMS shall display text corresponding to PA announcements, and shall be synchronized with the PA audio announcement.
- C. The Contractor shall be responsible for turnkey VMS sign installation at each BRT station platform. This shall include integration into the AIM<sup>®</sup> PA/VMS System located at 45 High St.
- D. WAN Connectivity from 45 High St. to the BRT stations shall be provided by the MBTA at the third floor of the DCAM Building located at 200 Arlington St in Chelsea.
- E. The Contractor shall provide LAN connectivity at the local station to support the passenger station sign networks.
- F. The Contractor shall provide all hardware and software interfaces required to connect signs to the AIM<sup>®</sup> PA/VMS System located at 45 High St.

##### **1.3 SYSTEM FUNCTIONAL DESCRIPTION**

- A. The VMS shall be amber color information display system that operates in conjunction with the AIM<sup>®</sup> PA/VMS system installed at 45 High St. This system provides a visual display of the audible announcements and messages, as well as additional text using multicolor LED technology. The technology used shall provide variable message

display capabilities for messages, including: public information, service, community, safety, security, events, news, sports, weather, and advertising messages. Messages may be composed of still or moving text or graphics that comply with the provisions of the Americans with Disabilities Act (ADA). The displayed text shall be variable in size and font, highly visible, and easy-to-read. The use of amber LED block technology allows superior message viewing in dim lighting, harsh and very bright interior lighting, including direct sunlight on the face of the display. The Visual Information System shall allow for a very wide viewing angle, thereby reaching a greater number of potential message viewers. The Visual Information System shall interface with and be controlled by the AIM<sup>®</sup> PA/VMS System to provide visual text messages synchronized with audible voice announcements.

B. Communications: The Visual Information System Communication Network shall require a 24-port 10baseT switch. The AIM<sup>®</sup> PA/VMS shall communicate with the station VMS units via the Ethernet switch. Signs shall be configured for one network (IP Ethernet connection) per sign network.

C. The passenger station VMS shall connect to the PA/VMS System via the MBTA WAN network. This interface shall be used to convey announcement activity information to the VMS that will display the message. The AIM<sup>®</sup> PA/VMS System shall allow the visual message display to be synchronized with the audible announcement for train arrival and all MBTA passenger station announcements.

1. The BRT Station VMS shall be configured for a minimum of 2 zones (inbound and outbound).
2. Zones for VMS shall consist of Sign Networks comprised of one IP Ethernet address per zone. Sign Network configurations and zone assignments will be dictated by the passenger station physical layout, project drawings and shall be submitted by the contractor during design.
  - a) All cable shall be shielded CAT6 or better.
  - b) Fiber optic cable shall be utilized for Ethernet cable runs longer than 300 feet.
  - c) All Ethernet connections shall conform to EIA/TIA-568 Standards.
  - d) A Sign Network shall be defined as one IP address with RS-422 sign interconnect.
3. Announcement Processing: Upon initiation of an announcement, the PA/VMS System shall provide the VMS with the required message codes and/or text, and the sign zones to which the announcement is to be displayed.
4. Message Creation: Messages, graphic images, animation and advertisement for display on the signs shall be created, edited, scheduled, changed, or deleted through the use of ARINC's AIM<sup>®</sup> software running on the PA/VMS System or a remote computer workstation attached to the network. This AIM<sup>®</sup> PA/VMS System software has the capability to:
  - a) Create message resources;



- b) View messages created on the computer screen before sending them to the VMS.
  - c) Create and maintain message databases;
  - d) Create and maintain a hierarchy of various messages - i.e. live, real-time, Scheduled and train arrival.
  - e) Schedule messages and target specific signs by location, time of day, day of week, frequency of display, etc.;
  - f) Set up program lists for various groupings of stations.
5. Display Graphics: The Visual Display System signs shall have the capability of displaying amber color in each LED pixel or dot. LED matrix shall be 32H x 240L. Features of the VMS signs shall include:
- a) Expandable (to 8 Mb minimum) variable message memory in the display;
  - b) Individually addressable VMS sign units;
  - c) Ethernet interface port with optical or TTL inputs to provide surge protection
  - d) RS-422 interface with optical or TTL inputs; to provide surge protection
  - e) Modular and weather-tight enclosures NEMA 4.
  - f) Light baffling to minimize glare and reflection for outdoor use;
  - g) Photo sensor built-in to vary display brightness with ambient light conditions;
  - h) Message delivery options including: scrolling up-down, right-left, left-right, down-up; instantaneous, burst, etc. and can be selected by software interface;
  - i) Built-in diagnostics;
  - j) Real-time clock with battery backup;
  - k) 512 Kbytes of FLASH memory that is user programmable for display software, built in fonts, pre-canned/prerecorded messages and user settings;
  - l) Multiple fonts and special effects generator.

#### **1.4 QUALITY ASSURANCE**

- A. ETL listed to UL Standards 48 and 1433
- B. NEC compliant
- C. FCC Class A Compliant
- D. ETLC listed to CAN/CSA 22.2

#### **1.5 SUBMITTAL**

- A. Submit following to Engineer for approval:
- B. Manufacturer cut-sheets and functional descriptions for electronic sign equipment, Ethernet Switches, fiber converters and all equipment required for turnkey solution.

- C. Specific plans showing details of electronic sign enclosure location, mounting, cable and conduit routing, Sign Network Configurations and sign orientations.
- D. Point-to-point wiring diagrams for all equipment furnished under this Section.
- E. Ten (10)-maintenance manuals.
- F. Detailed test procedure form and test results.
- G. The electronic LED display manufacturer shall provide a complete technical submittal within 30 days of contract award and shall not proceed with LED Matrix manufacture until the Engineer has approved the submittal.

## PART 2 - PRODUCTS

### 2.1 PASSENGER STATION ETHERNET SWITCH DEVICES

- A. Passenger Station, Communications Room Ethernet Switch Specification:

GENERAL SPECIFICATION	
ITEM	DESCRIPTION
General Description:	24 10/100Mbps + 1000Mbps Switch 24 10/100 ports + two 1000BASE-T ports Up to 8000 MAC Address Table 8 MB memory architecture shared by all ports Up to 16 MB SDRAM & 8 MB Flash memory
Standards	IEEE 802.1x support IEEE 802.1w IEEE 802.1s IEEE 802.3x full duplex on 10BASE-T, 100BASE-TX, and 1000BASE-T ports IEEE 802.1D Spanning-Tree Protocol IEEE 802.1p class-of-service (CoS) prioritization IEEE 802.1Q VLAN IEEE 802.3 10BASE-T specification IEEE 802.3u 100BASE-TX specification IEEE 802.3ab 1000BASE-T specification IEEE 802.3ad IEEE 802.3z 1000BASE-X specification

	RMON I and II standards SNMPv1, SNMPv2c, SNMPv3 (planned future support)
<b>Ports</b>	24 10/100 ports + two 1000BASE-T ports
<b>Speed</b>	10/100Mbps + 1000Mbps
<b>MAC Address Table</b>	Up to 8000
<b>Buffer Memory</b>	8 MB memory architecture shared by all ports Up to 16 MB SDRAM & 8 MB Flash memory
<b>Security</b>	<p>Filtering of incoming traffic flows based on Layer 2, Layer 3 or Layer 4 access control parameters (ACPs) prevents unauthorized data flows.</p> <p>The following Layer 2 ACPs or a combination can be used for security classification of incoming packets: source Media Access Control (MAC) address, destination MAC address, and 16-bit Ethertype.</p> <p>The following Layer 3 and Layer 4 fields or a combination can be used for security classification of incoming packets: source/destination IP address, TCP source/destination port number, User Datagram Protocol (UDP) source, or destination port number. ACLs can also be applied to filter based on DSCP values.</p> <p>Time-based ACLs allow configuration of differentiated services based on time-periods.</p> <p>Private VLAN edge provides security and isolation between ports on a switch, ensuring that voice traffic travels directly from its entry point to the aggregation device through a virtual path and cannot be directed to a different port.</p> <p>Support for the IEEE 802.1x standard allows users to be authenticated regardless of which LAN port they are accessing, and provides unique benefits to customers who have a large base of mobile (wireless) users accessing the network.</p> <p>SSHv2 and SNMPv3 provide network security by encrypting administrator traffic during Telnet and SNMP sessions. SSHv2 and the crypto version of SNMPv3 require a special crypto software image due to US export restrictions</p> <p>Port Security and unicast MAC filtering secures the access to a port based on MAC addresses. The aging feature of port security removes the MAC address from the switch after a specific timeframe to allow another device to connect to the same port. Unicast MAC filtering allows non-IP packets to be filtered as well.</p>
<b>Cabling</b>	<p>10BASE-T ports: RJ-45 connectors; two-pair Category 3, 4, or 5 unshielded twisted-pair (UTP) cabling</p> <p>100BASE-TX ports: RJ-45 connectors; two-pair Category 5 UTP cabling</p> <p>1000BASE-T ports: RJ-45 connectors; four-pair Category 5 UTP cabling</p> <p>100BASE-FX ports: MT-RJ connectors, 50/125 or 62.5/125 micron multimode fiber-optic cabling</p> <p>1000BASE-T, 1000BASE-SX, -LX/LH, -ZX GBIC-based ports: SC fiber connectors, single-mode or multimode fiber</p>
<b>LEDs</b>	<p>Per-port status LEDs: link integrity, disabled, activity, speed, and full-duplex indications</p> <p>System status LEDs: system, RPS, and bandwidth utilization indications</p>
<b>VLAN Support</b>	Yes
<b>Power</b>	<p>AC input voltage: 100 to 127, 200 to 240 VAC (autoranging)</p> <p>AC input frequency: 47 to 63 Hz</p> <p>DC input voltages +12V @ 4.5A (with option)</p>
<b>Temp</b>	0°C to 45°C (32°F to 113°F)
<b>Humidity</b>	10 to 85% (no condensing)

B. Passenger station communications room Ethernet switch shall be CISCO Catalyst 2950 Model WS-C2950T-24 or approved equal.

C. All other Ethernet and RS-422 devices including fiber converters, hubs etc. shall be temperature and vibration hardened adequate for the subway environment. Requirements shall include:

1. Operating Shock and Vibration: Meets Bellcore GR-63-CORE Sections 4.4.1 and 4.4.3
2. Ambient Temperature: -40° to 160°F (-40° to 70°C)

3. Ambient Relative Humidity: 10% - 95% (non-condensing)
4. SNMP Manageable (Ethernet devices only).

D. Contractor shall submit all communication devices required for turnkey installation prior to approval.

## 2.2 VISUAL MESSAGE SIGN DISPLAYS

A. Variable Message Signs, general - The LED matrix shall be composed of an array of replaceable LED modules. The VMS unit shall use amber LED's. Display Characteristics shall be as follows:

1. General Description: Variable Message Sign, Amber, with black off-state LED Full Matrix Multi-Line Display, with full text/graphics capability, outdoor weatherproof Nema-4 enclosure
2. Sunlight Readability – Due to the inconsistent rating of LED brightness by manufacturers, no minimum candela rating is specified. The outdoor displays should be readable in direct sunlight. The contractor shall provide Sun Shades where required or where signs are in direct sunlight.
3. LED Matrix size: 32 H x 320 L
4. Cabinet Size: 16.125"H x 76.875"W x 10"D
5. LED Pixel Size & Pitch: Pixel dimension 8.0mm, pitch 7.6mm
6. LED Wavelength: Amber, 593 nm.
7. Minimum Viewing Angle: >=30 degrees horizontal x 30 degrees vertical
8. VMS Addressability – Each VMS shall be individually addressable via a true TCP/IP interface.
9. VMS Message Storage – minimum of 12Mb memory
10. Display Capability: Text, graphics, logos, basic animation, multiple font's styles and sizes.
11. Fonts - An extensive font set shall be included with the VMS. All VMS fonts shall meet ADA requirements for signage. ADA Section 4.30.2 and 4.30.3 describe requirements for width-to-height ratio, stroke width-to-height ratio, and character height. Fonts shall include a robust character set containing all characters required to express messages in standard Spanish and English languages. The character sets include upper case, lower case, numerical digits, non-alphabetic, and non-numeric special characters.
12. VMS Self Diagnostics – Each VMS display shall be capable of self-diagnosis and communicating its operational, temperature and equipment status to the AIM<sup>®</sup> PA/VMS System. The AIM<sup>®</sup> PA/VMS System shall automatically request status from individual VMS displays. In addition to identifying errors, the status reports shall also serve as an independent and redundant means of verifying the message content of each VMS, allowing the effects of any spontaneous communication errors to be corrected. The proper execution of commands sent from the AIM<sup>®</sup> PA/VMS

B. System can be verified. Through the status reporting, the Administrator shall be in a position to query the entire system, and automatically take corrective action if necessary.

1. VMS Environmental Design - The proposed VMS equipment shall be designed and manufactured to withstand a harsh transit environment including the effects of weather conditions on outdoor deployed equipment. All Variable Message Signs shall be certified to the NEMA 4 standard. Operating temperatures will be from -20° C to

C. +50° C (-4° F to 122° F). VMS outdoor units shall be waterproof and sealed against particulate matter invasion such as steel and other metallic particulate matter typically found in a transit environment. The hardware will be modular and designed for ease of service.

1. The presence of ambient radio signals and magnetic or electromagnetic interference including those from power lines, transformers and motors, shall not impair performance of the display system. The display system shall not radiate electromagnetic signals that adversely affect any other electronic device
2. Internal display component hardware (nuts, bolts, screws, standoffs, rivets, fasteners, etc.) shall be fabricated from stainless steel, aluminum, nylon, or other durable corrosion-resistant materials suitable for the signage application

D. Specific Variable Message Sign Characteristics

GENERAL INFORMATION	
ITEM	DESCRIPTION
General Description:	Variable Message Sign, Amber Monochrome LED Dot Matrix Multi-Line Display, with full text/graphics capability, outdoor weatherproof enclosure, double sided display
LED Description:	LED's are installed in replaceable modules. LED technology is Amber AlInGaP.
LED Life:	100,000 hours MTBF.
LED Pixel Size & Pitch:	Pixel dimension 8.0mm, pitch 7.62mm
LED Brightness:	1500 cd/m <sup>2</sup> Typical. 64 levels automatic or manual control
LED Wavelength:	Amber
Minimum Viewing Angle:	>=30 degrees from the center viewing axis
Display Area Size:	32 pixels high X 240 pixels wide 4 lines at 40 characters each line
Ambient Light Adjust	Automatic dimming of LED's in darkened ambient light to prevent eyestrain.
Display Capability:	Alphanumeric Text, Data Field Support, Bit Map and Font Based Graphics.
Clock:	Built in time and day and date. Clock and date can be updated by remote command message from Operations Control Center. In the event of a power loss to the VMS, time and date are capable of automatic update once communication is restored.
Message Storage:	Minimum of 12Mb memory
Fonts:	Normal fonts have ADA compliant aspect ratios. Bold and Wide versions also available. Multiple fonts and graphics may be displayed simultaneously based on applications software.
Background:	Matte black

Display Attribute Selections:	Scrolling (left to right, right to left, top to bottom, bottom to top), variable scrolling speed, circulate (continuous scroll in either direction), automatic centering, justify left or right, instantaneous pop-up (no scrolling of any kind), blinking (character, word, message), no blink.
Sign Network:	Individual sign network, within a zone at a station, shall consist of one Ethernet IP address and a daisy chain configuration to additional signs utilizing RS-422.

SPECIFICATIONS	
ITEM	SPECIFICATIONS
Design Approach:	Weathertight design to withstand the harsh transit environment. NEMA 4 rated.
Humidity Range:	0% to 95% RH, non-condensing
Operating Temperature:	-20 to 50 degrees C
Storage Temperature:	-40 to 85 degrees C
Conformal Coating:	Circuit boards conformal coated to MIL-I-46058C
Case size:	16.125" H x 10" D x 76.875" W for four line, 16 LED each Double Face (DF) display.
Mounting:	Side mount brackets for overhead mounting
Case Material:	Aluminum
Weight:	Approximately 130 pounds (DF)
Double Side Capability:	Two displays are mounted back to back. Brackets to be provided by contractor or manufacturer supplied.
Display Face Plate:	Polycarbonate, gray, 0.236", field replaceable
Corrosion Resistance:	All metallic housing components and fasteners shall be corrosion resistant
Service Access:	The display electronic components shall be mounted to a metal plate (backplate) for easy removal. Backplate is accessed from the front of the enclosure. All external screws are of vandal-resistant, non-corrosive design, key lock entry. Keyed alike existing signs deployed at the Authority.
Power Requirements:	120VAC, 2.1 Amps, 250 Watts (SF) 120VAC, 4.2 Amps, 500 Watts (DF)
Diagnostics Communications Interface:	Internal port for diagnostics interface. No external port due to weatherseal integrity and vandalism/security issues.
CPU	Power PC Architecture 200MHz CPU Clock (280 MIPS)
Ethernet Support	The display shall support a socket based communications model using TCP/IP, DHCP, Telnet, and SNMP.
RS-422	RS-422 for inter-network sign network communication.
Diagnostics	Diagnostic services through the software API interface.
Firmware Upgrades:	The Display Firmware shall be remotely upgradeable.
Electrical Safety Certification	Certified to UL-48 and to FCC Part 15 Class A

E. The Visual Message Signs shall be Daktronics Galaxy AF-6300 or approved equal.

## **2.3 SIGN ENCLOSURE**

- A. Shall be constructed of 0.090" (minimum) thick aluminum and all joints welded together.
- B. To maintain NEMA 4 certification, no external ventilation is allowed.
- C. Enclosure paint scheme shall be submitted for approval.

## **2.4 SIGN CONTROL**

- A. The controller shall be able to run independently from the Head end AIM<sup>®</sup> PA/VMS System.
- B. Communication protocol shall support other products from the vendor such as other outdoor or indoor displays of varying sizes and/or colors.
- C. The controller shall be able to be operated via Ethernet communication and RS-422.
- D. Each controller shall be connected to a light sensor allowing each LED display to automatically adjust a minimum of 64 levels of brightness according to display direction and lighting conditions.
- E. The controller shall allow connection to a temperature sensor that provides accurate site temperatures.

## **2.5 CABLES**

- A. All sign manufacture recommendations for power and communications cable shall be followed.
- B. Cables shall adhere to EIA/TIA 568 and RS-422 standards.
- C. AC cable and power to VMS shall be as specified and provided under this contract.
- D. Control cable shall be CAT 5 STP made of jacketed, individually shielded twisted pairs as recommended by manufacturer for RS-422 data rate and distance, except where fiber connection is specified. All Sign manufacture recommendations shall be adhered too.
- E. Where required, a multi mode 6-strand fiber optic control cable shall be used in placed of the CAT 5 cable. When fiber is required the contractor shall provide a fiber converter in the enclosure and in the communications room.

# **PART 3 - EXECUTION**

## **3.1 INSTALLATION**

- A. Electronic Signs

- B. Electronic signs shall be installed in locations as shown on approved Drawings. Sign enclosures shall be mounted in accordance with approved site specific detail plans.
- C. Conduit on station platforms to the Communication Rooms and other areas will be provided. Conduit, conduit fittings and connections shall be furnished and installed by Contractor. Conduit entrances to electronic sign enclosures shall be made weather tight by use of a Meyers type hub.
- D. Cables shall be installed within rigid steel conduit. Conductors shall be identified by color and listing its function. Cable routing distances between signs and the Communications Room shall be kept at a minimum to ensure accurate communications. The Engineer shall approve cable routing distances. Power cable(s) shall be routed in a separate conduit from data communications cable.

### **3.2 TESTING**

- A. Notify Engineer at least five days in advance of electronic sign system test so that Engineer or his representative may be present at this test if he so elects. Upon completion of test, submit a certified test report to Engineer.
- B. Note any system deficiencies observed under testing in certified test report. All deficiencies shall be corrected and system shall be re-tested. A sequential test report shall be submitted.
- C. Factory tests each electronic sign, prior to integration with mounting assembly. Perform full functional testing.
- D. Functionally test complete system, with Engineer present, as required. If any deficiencies are observed, correct same as described herein. Submit as-built drawings and maintenance manuals one week prior to final scheduled testing.
- E. Functionally test complete system, with Engineer present, as required. If any deficiencies are observed, correct same as described herein. Submit as-built drawings and maintenance manuals one week prior to final scheduled testing.
- F. Functional tests shall include full integration with the existing MBTA AIM<sup>®</sup> PA/VMS System located at 45 High St.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.01 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of the passenger station variable message sign system.

### **END OF SECTION**



**SECTION  
16840  
CLOSED CIRCUIT TELEVISION SYSTEM**

**PART 1 - GENERAL**

**1.1 GENERAL DESCRIPTION**

- A. This section specifies the expansion of the MassDOT-MBTA (MBTA) Closed Circuit Television (CCTV) system. This expansion shall consist of CCTV equipment to be installed as part of MassDOT's Chelsea Silver Line Gateway project. The MBTA CCTV system is a real time IP video system utilizing IP based cameras and legacy analog cameras that are encoded for transmission over the MBTA's IP network. The Video is viewed throughout the MBTA system using the VidSys VidShield/RiskShield (VidSys) Physical Security Integration Management (PSIM) software client.
- B. The CCTV system utilizes the MBTA's Security Wide Area Network (SWAN) and MBTA's Wide Area Network (WAN) as a means of transmitting IP video to various locations throughout the MBTA system for viewing and recording. The system expansion shall incorporate IP fixed cameras, Multi-Stream Megapixel CCTV Cameras, Network Video Recorders (NVRs)/Video Management Systems (VMSs), the VidSys software, network switches, codecs, and any other hardware or software required to transmit, receive, and store video over an IP network for a complete and functional system.
- C. The VidSys software client allows MBTA personnel to access live and recorded video streams from any camera, encoder, DVR, or NVR on the system, and to create and store video clips and snapshots locally. The VidSys client is currently installed on multiple computer workstations within the six (6) Hub Centers, Operations Control Center, and on individual computer workstations throughout the MBTA network.
- D. This contract requires the Contractor to coordinate with the MBTA Communications Department and MBTA's CCTV Maintenance Contractor (MCMC) via the MBTA project manager to inform them of, and schedule work associated with, integrating alarms and video streams with the existing VidSys head end system.
- E. The Contractor shall fully integrate all of the new cameras and video streams into the VidSys system and will require geospatially placing icons onto new and existing system maps. The icons shall allow access to the camera's controls and video streams. The functionality shall match that of the existing integrated cameras. All camera device monitoring shall be activated and tested, this shall include but not be limited to; status, loss of video, faults, failures, alarms, and all tampering related events/alarms.
- F. All CCTV cameras/endpoints shall be entered into the VidSys system with nomenclature submitted to, and approved by, the MBTA, and shall include GPS coordinates of each endpoint. The contractor shall utilize GPS coordinates accurate to 3 feet or locate the endpoints on map based graphics in the exact position. All maps required to properly represent the endpoint locations shall be in scaled format and may utilize existing MBTA CAD contract drawings. It is the Contractor's responsibility to convert/import/translate the CAD drawings into a format that is applicable for the project; all extraneous information shall be removed from CAD drawing for a clear representation of the equipment installation. Maps shall include labels stating BRT lines and directions, location of devices,

camera view details, etc. All device icons shall be based on the MBTA standards; if a standard has not yet been established for a device, then the Contractor shall work with the MBTA to develop an icon standard for that device.

- G. The Contractor shall configure all CCTV cameras and encoders to be set up to dual stream H.264 images. One stream shall have 1.3 Megapixel (MP) resolution (for station cameras) and 5 MP (for busway cameras), and a frame rate of 8 fps or greater for NVR recording; and the other stream shall have a resolution of 720p, and a frame rate of 15 fps or greater for live viewing. Before CCTV camera set-up, the Contractor shall verify all camera settings with the Engineer, or an MBTA representative. All live streams shall be multicast streams sent directly from the camera to the clients, the VMS/NVR shall facilitate the connection, but the stream shall not be routed or trans-coded through the NVR hardware in order to limit network usage, and to avoid the installation of extra server hardware. All recorded streams shall be via multicast streams from the camera to the multiple NVR recording locations in order to limit network usage. The compression on a camera shall not exceed 30%, unless approved by the Engineer.
- H. The CCTV system is currently in use by MBTA personnel, and is considered a critical system for MBTA Operations and security. All system improvements and changes must be coordinated in advance so as to not impact operations. This may require the Contractor to perform installation, testing, upgrades or system outages at off-peak or non-revenue times.
- I. For the purpose of Configuration Management, the Contractor must inform the MBTA of the length of time the Contractor will be making any system modifications. The dates and length of downtime of the system must be submitted in writing on the Contractor's letterhead to the Communications Department and the MBTA's MCMC via the MBTA project manager, and must be approved by those groups. The Contractor shall complete all background maps, plan all alarms, and submit all licenses prior to doing any work on the MBTA's VidSys system. The Contractor must submit, at least 30 days in advance, for a two week window in which to complete all work on the MBTA's VidSys system; the Contractor may submit for additional time, but time may be limited due to other active contracts needing access to the system. The Contractor must complete a backup of the system prior to working on the system. The Contractor shall label the backup media with the contents, date, and time of the backup. The Contractor must maintain this backup for at least 120 days after the updated software is put into use. It is the Contractor's responsibility to have the system back online prior to the start of revenue service.
- J. The Contractor shall provide all configuration/setup/programming of new and existing video system components identified in this specification section for a complete working system. Device configuration settings shall be submitted to the Engineer and the MBTA for approval prior to installation.
- K. The Contractor shall perform preliminary visual adjustments of each camera during installation to account for lighting conditions, desired view, and other environmental conditions. The Contractor shall also perform a final camera tuning and field of view adjustment to all cameras installed under this project within 30 days after the video system has been installed, positioned, and have been recorded.
- L. The Contractor shall have present during the duration of the Contract, a certified network engineer with a minimum of 5 years' experience in networking of large-scale wide area network projects to be involved with all aspects of system integration of networked devices. The Contractor must submit this key person's resume for approval by the MBTA within 10 days from Notice to Proceed. No work shall be allowed to proceed with

components having a network interface if this key person is not involved. This person shall be on-site at all times when network integration is taking place. Failure to have this person on-site shall cause the MBTA to immediately stop work until this person is on-site, at the Contractor's expense. Shall this person no longer work for the Contractor, the Contractor shall immediately inform the MBTA and a replacement shall be submitted at that time.

- M. The Contractor shall have on site a person who is certified by the manufacturer of the individual subsystems (NVR, Lenel, and VidSys) for all work on these systems. The Contractor must submit each person's resume for approval by the MBTA within 10 days from Notice to Proceed. No work shall be allowed to proceed on these systems if a certified person is not involved. This person shall be on-site at all times when work on these systems is taking place. Failure to have this person on-site shall cause the MBTA to immediately stop work until this person is on-site, at the Contractor's expense. Shall this person no longer work for the Contractor, the Contractor shall immediately inform the MBTA and a replacement shall be submitted at that time.
- N. All Licenses necessary for NVR, VidSys, Lenel, and any other integration shall be supplied by the Contractor for all CCTV, Access Control, or other installed equipment, and for existing equipment as described in these specifications or on the Contract Drawings.
- O. The Contractor shall coordinate SNMP Community Strings for all SNMP capable devices with the MBTA. The Contractor shall configure the Community String in all SNMP capable devices prior to deploying in the field. Any improper configurations shall be the sole responsibility of the Contractor to correct and shall be corrected within 48 hours of notification.
- P. The MBTA currently has an existing NiceVision version 10.x system with over 1,000 active channels and 250 DVRS/ NVRS located throughout the system. The Contractor's work for this contract shall have no impact to any of this existing equipment. All existing cameras and recording devices currently operating on the system shall remain operational with the addition of cameras and recording systems added per this contract. If any additional hardware, software, licenses, programming, configuration, setup or testing is required to install the new equipment per this contract while maintaining the existing NiceVision equipment, they shall be provided by the contractor at no additional cost to the MBTA. Extensive coordination will be required with the MBTA to ensure that there is minimal downtime in the existing camera live viewing, recorded viewing, and recording functions.

## **1.2 SUBMITTALS**

- A. Prior to approval of the CCTV system hardware and software components, the Contractor shall submit the proposed equipment vendors' qualifications, and a written statements from the vendors acknowledging that the hardware and software to be supplied shall meet all functionality as required within this specification.
- B. The Contractor shall submit a typical site block diagram indicating hardware and software components that shall be installed at all locations.
- C. The Contractor and vendor shall be prepared to demonstrate the equipment functionality within two weeks of submission and prior to vendor/equipment approval. The Contractor

shall plan to demonstrate how this proposed equipment meets or exceeds all functional/performance requirements of the proposed vendor solution.

- D. If the VMS chosen by the vendor is not one currently in use by the MBTA, then the Contractor shall, within two weeks of NTP, demonstrate to the Engineer the dual and simultaneous recording capabilities of the system via a single multicast stream from the camera and demonstrate that the clients can view a separate live multicast stream sent from the camera. This demonstration shall take place at a location in the metro Boston area. The demonstration will require that recording of two cameras occurs simultaneously, one viewing a digital clock with a readout in hours; minutes; and seconds and the other viewing the client computer. An Ethernet failure will be simulated on the primary recording and management servers for ten minutes. Recording and management servers will then be reconnected, and the video recorded during the ten minute failure simulation will then be viewed to ensure that there was no loss of video. During the ten minute simulated failure, the live video from the cameras will be brought up on the screen through the VMS client to be viewed. The same connection loss scenario will then be tested for the loss of connectivity to the secondary server. There shall be at least two clients active in the room and the camera settings in the camera's setup page and in the VMS/NVR management interface shall be viewed to ensure proper multicast setup.
- E. Submit descriptive literature, including manufacturer specification sheets, for all CCTV equipment and software functionality and materials proposed for use in accordance with the requirements of this Section for approval prior to fabrication, assembly, installation and testing.
- F. Also, submit the following to the Engineer for approval: Network diagram of complete system, illustrating the proposed configuration and interconnections. The Network diagram shall include detailed network architecture of all related IP devices, IP schema, device bandwidth, configuration and routing requirements.
- G. Prior to ordering any equipment as required under this Section, submit three (3) copies of the following to the Engineer for approval:
1. Full technical data and manufacturer cut sheets for all equipment.
  2. Site specific plans showing details of the following:
    - a. Camera enclosure location and mounting details.
    - b. Cable and conduit details.
    - c. Light intensity ranges throughout the surveillance areas (determined by actual field tests).
    - d. Camera field of vision.
      - 1) Submit schematic and wiring diagrams complete with terminal numbers.
      - 2) Submit NVR storage recording calculations, in days and hours, based on motion sensing configuration. Define camera image motion zones and activity levels.
      - 3) Submit procedures for programming and troubleshooting.
      - 4) Submit full interconnect diagram for overall system, including interface connections to existing equipment.
      - 5) Submit configuration plan for camera/NVR access levels.

- H. Supply maintenance instruction manuals to the Engineer including information regarding installation and maintenance as follows:
1. Operational Description and Procedures
  2. Troubleshooting and Routine Test Procedures
  3. Adjustments and Alignment Procedures
  4. Wiring Diagrams, Tables and Schematics
- I. Prior to installing any equipment, submit to the Engineer for approval six (6) copies of a detailed field test procedure intended to ensure all components of the system are functioning properly, in accordance with these Specifications and the Contract Drawings. The tests performed shall include the tests outlined in Paragraph 3.3 of this Section. The detailed test procedure shall include a description of all test equipment to be used and specific measurements and/or pass/fail criteria for each test.
- J. Factory Tests: Submit at completion of factory testing, including program software, and six certified copies of test results.
- K. Test Procedures and Reports: Full details shall be submitted of the scheduled tests and the expected duration of all test procedures. Samples of all test report forms, and full details of the methods that the raw test data is to be reduced, shall be approved by the MBTA before commencement of system testing to be furnished under this Contract.
1. The test report shall identify the name of manufacturer, model numbers, serial numbers, and the last date of calibration of test instrumentation. Documentation shall be furnished to verify that test instruments have been calibrated not more than nine months prior to the tests. If a test instrument does not require calibration, it shall be highlighted in the report.
  2. The test report shall include a list of attendees.
  3. Certified test results for the system components tests shall be submitted within 30 days after the completion of each test. No equipment shall be released for shipment until certified test data is approved by the Authority. Copies of approved test procedures, raw data measured results, calculations and all data derived from tests shall be included as part of report. All test data shall be bound in one report. The test report shall be indexed and cross-referenced in an easily understood manner.
- L. Certificate of Compliance: Submit a certificate of compliance that all components furnished meet the requirements specified herein.
- M. Operation and Maintenance Manuals shall be submitted as listed below:
1. The Contractor shall furnish an operation and maintenance manual for each piece of equipment, unless otherwise specified herein. The manual shall be provided in both hardcopy and on compact disk. The MBTA Communications Department, prior to submittal, shall approve the software utilized. The following identification shall be inscribed on the cover: the words "OPERATING AND MAINTENANCE MANUAL", the name and location of the project, the name of the Contractor, the contract number, revision, and date. The manual shall include the names, addresses, and telephone numbers of each subcontractor furnishing or installing equipment. In addition, include the local representatives for each item of equipment. The manual

shall have a table of contents and index. The manual shall be assembled to conform to the table of contents, including tab sheets placed before instructions covering the subject. The instruction sheets shall be legible with large sheets of drawings folded in. The contents of the manual shall also be available on-line by means of a help screens.

2. The Contractor shall submit to the Engineer for approval three copies of the preliminary operation and maintenance manual at least 30 days prior to shipment of first relevant unit. After approval of the preliminary submittal and having made all necessary corrections and amendments as required, the Contractor shall supply the Engineer with six additional copies of the approved dated operation and maintenance manuals. One set of master camera-ready copy shall be included as one of the six copies to permit additional copies to be made. The master camera-ready copy shall be clearly marked as such on the outside. One manual shall be provided on compact disk. The MBTA Communications Department, prior to submittal, shall approve the software utilized. The manual shall provide a clear explanation of the theory, operation, and maintenance of the equipment accompanied by photos and schematic, wiring and mechanical assembly diagrams, as required. The manual shall be indexed and cross-referenced in an easily understood manner. The manual shall be loose leaf bound and shall include the following information:
  - a. Operating instructions.
  - b. Troubleshooting and fault isolation procedures for on-site level repair.
  - c. System equipment removal and replacement procedures.
  - d. A list of the replaceable components.
  - e. A test procedure to verify the adequacy of repair work.
  - f. A preventive maintenance schedule and instructions for the replacement of any electrical equipment.
  - g. A preventive maintenance schedule for inspection, removal, and replacement for each component.
  - h. A list of special tools provided by the manufacturer.
  - i. A list of recommended tools and test equipment as required for performing all maintenance tasks.
  - j. Recommended spare parts list for one year's operation.
  - k. Interchangeable parts list-showing parts common to items of equipment.
  - l. Equipment manufacturers' descriptive literature including catalog cut sheets.
  - m. As-built working drawings.
  - n. System component approved factory test reports.
  - o. The latest service bulletins with dates that describe service procedures.
  - p. Camera configuration, troubleshooting, fault diagnostics and default settings.
  - q. The NVR software programming, troubleshooting, fault diagnostics, and shutdown procedures.
  - r. All software screens to be utilized for graphic representation of physical locations of equipment installation.
  - s. Update Operations Manual for CCTV system software modifications provided under this Contract.

### **1.3 WARRANTY**

- A. All work shall include a three (3) year Contractor's warranty, per FAC64 that includes parts and labor to begin on the date of MBTA Project Manager's system acceptance.
- B. The Contractor is responsible for a four hour response time from time of notification by MBTA of any device, or system, being down or not properly functioning. The Contractor shall be notified by telephone or email to their support team.
- C. The Contractor shall repair all issues within 24 hours of reporting of the issue.
- D. The Contractor, shall, at the request of the MBTA, install software and firmware updates across all Contractor installed or modified systems or devices for the duration of the warranty period.
  - 1. The Contractor shall alert the MBTA to the length of downtime of any systems or devices that will occur during upgrades.
  - 2. The Contractor shall fix any issues caused to any systems during the upgrades.
  - 3. The Contractor shall backup all system databases prior to performing upgrades.
- E. A Service Level Agreement (SLA) for the length of the warranty shall be included for all software requiring an SLA.

### **1.4 NETWORK SWITCHING**

- A. All network switches shall be configured by a member of the MBTA IT Department.
- B. All network switches shall be installed in place by the Contractor.
- C. The Contractor shall provide, for approval by the MBTA, a schedule of dates on which the network shall be active at each location within 30 days after NTP. The Contractor shall have all uplink fiber optic and/or copper cables fully tested and labeled, and submit a test report to the MBTA Communications Department, at least 10 working days prior to the date the station network needs to be active. The Contractor shall have all 120VAC power and 48VDC power supplies and equipment cabinet power shutoffs in place and tested at least 10 days prior to the date the station network needs to be active. The Contractor must deliver cable test reports and confirmation of active power and of power shut-offs being in place to the MBTA Security and IT Departments at least 10 days prior to the date the station network needs to be active. The dates on which each station network needs to be active must be separated by at least 10 days.
- D. The Contractor shall properly and completely fill out MBTA IT Department forms for switch configuration and deliver to the MBTA IT Department at least 15 working days prior to the date the station network needs to be active.
- E. No network switches at any station location shall be installed until the uplink cabling is tested, and ready, and power is tested, and ready, at all cabinet locations within the station. No network switches shall be configured or installed until the MBTA IT Department has received all properly and completely filled out switch configuration forms. Any delay caused by the Contractor not having any item stated above complete will be the responsibility of the Contractor, and will not be reason for a schedule extension.

## **1.5 REGULATORY REQUIREMENTS**

- A. Comply with all applicable requirements of the following:
  - 1. National Electrical Code
  - 2. Massachusetts Electrical Code
  - 3. NFPA 130
  - 4. TIA
  - 5. IEEE
  - 6. ANSI
  - 7. ETL
  - 8. FCC
  - 9. ISO
  - 10. UL
  - 11. IEC
  - 12. RoHS

## **1.6 RELATED SECTIONS**

- A. Section 01010 SUMMARY OF WORK
- B. Section 13700 ELECTRONIC ACCESS CONTROL SYSTEMS
- C. Section 16050 BASIC ELECTRICAL
- D. Section 16826 COMMUNICATIONS CABLE ROUTING SYSTEMS

# **PART 2 - PRODUCTS**

## **2.1 GENERAL REQUIREMENTS**

- A. Furnish all items of the material, design, sizes, and ratings shown on the Contract Drawings and herein specified.
- B. All CCTV cameras and NVRs installed under this contract shall be integrated and fully functional with the VidSys software, and the integration shall be approved by VidSys. If the Contractor wishes to use CCTV cameras and/or NVRs that meets the specifications and are not currently integrated into the VidSys software, then they must have the equipment integrated, and the integration approved by VidSys at no additional cost to the contract, and without any contract time extension.
- C. All CCTV Cameras installed under this contract shall be integrated into the proposed NVRs. If the Contractor wishes to use a CCTV Camera that meets the specifications and is not currently integrated into the proposed NVRs, then they must have the CCTV Camera and/or Encoder integrated at no additional cost to the contract, and without any contract time extension.



- D. Any CCTV camera and NVR installed under this contract must be an open protocol device and the manufacturer must provide an SDK to other device and software manufacturers to allow the integration of the device.
- E. The Contractor shall be responsible for all software and licensing necessary for achieving the described functionality.
- F. All firmware and software shall be updated to the newest version prior to the close of the project.
- G. All CCTV cameras mounted on station platform and bicycle rack structures shall be wired to operate over CAT6 UTP cable using PoE. In the event that field conditions such as conduit routing deviations cause cable distance for any station and/or bicycle rack camera to exceed 328 ft., the contractor shall furnish and install CAT6 PoE extenders to accommodate the additional cable length.
- H. PoE Surge Suppressors shall be furnished and installed for all security and communications equipment connected to station communications equipment enclosures using CAT6 UTP cables.
- I. All busway pole-mounted cameras shall be wired for local power (120VAC) and signal transmission over multi-mode fiber to corresponding station communications equipment enclosures as depicted in the Contract Drawings. Power for pole-mounted cameras shall be installed by the Electrical Contractor responsible for busway lighting pole power circuitry. All transformers, power supplies, signal transceivers, PoE injectors, and other ancillary equipment necessary for operation of pole-mounted CCTV cameras shall be housed in outdoor-rated pole-mounted equipment enclosures (one per camera) as depicted in the Contract Drawings. Local low-voltage conduit and cable connectivity between pole-mounted equipment enclosures and pole-mounted CCTV cameras shall be furnished and installed by the Security Integrator. All exposed conduit pathways between pole-mounted enclosures and pole-mounted CCTV cameras shall be weather-tight and appropriately sized, and include drip-loops to prevent moisture infiltration.

## **2.2 MATERIAL**

- A. All material shall be new and unused commercial off the shelf products and the workmanship shall be in accordance with the highest standards of the electronic equipment industry. Bids will be accepted only for new and current equipment. Equipment discontinued by the manufacturer shall not be accepted. All components shall be UL listed.
- B. Equipment purchased under this Section shall comply with applicable EIA standards and the manufacturer's warranties against material and workmanship.
- C. Supply all equipment capable of meeting the performance requirements within the MBTA transit system environment, subject to temperature, electromagnetic interference, humidity, vibration, and light conditions typically encountered.

## **2.3 MANUFACTURER/CONTRACTOR EXPERIENCE**

- A. Manufacturers supplying IP video and recording equipment shall have a minimum five years' experience in the IP video market. Manufacturer shall have experience in design and implementation of systems of similar size and complexity.

- B. Upon award of Contract, the manufacturer shall agree to support all installed equipment and software for a minimum 5 years after system acceptance. This shall be submitted in a formal letter to the MBTA Project Manager from the manufacturer.
- C. The Contractor installing the IP video equipment must have experience in IP video technology and must have prior experience in implementing an IP video network of similar complexity and size.

## **2.4 CCTV CAMERA MOUNTS**

- A. All CCTV camera mounts shall be designed by the manufacturer for the sole purpose of mounting the CCTV cameras specified herein.
- B. All CCTV camera mounts shall be type as stated on the Contract Drawings. Camera mounts that are listed as To Be Determined in field will be decided on a site walk with the Engineer and the Contractor.
- C. CCTV camera arm and pendant mounts shall include internal wire ways to protect cable as it transitions from conduit to the camera housing.
- D. CCTV camera arm and pendant mount bases shall be designed and constructed for the purpose of supporting the proposed arm or pendant mount.
- E. The Contractor or Contractors responsible for furnishing and installing CCTV cameras shall verify that the proposed CCTV equipment and enclosure mounts meet manufacturers' recommendations for safe and secure mounting of the equipment in accordance with applicable building code and/or standards. This shall include (but not be limited to) wind-load and seismic calculations.
- F. All CCTV camera mounts shall match the color of the CCTV Camera housing to which it is attached.
- G. Mounting hardware shall conform to Section 16050 of these specifications.
- H. Any non-standard camera mount must be submitted for approval.
- I. The Security Integrator shall furnish and install all necessary hardware and fasteners for secure installation of pole-mounted CCTV cameras and associated equipment enclosures per manufacturer recommendations. See Electrical Contract Drawings for lighting pole details and dimensions.

## **2.5 SECURITY/CCTV NETWORK SWITCH**

- A. The Security/CCTV Network Switches shall be fully compatible with the MBTA's existing Security Wide Area Network (SWAN) infrastructure.
- B. Each of four Station Communications Equipment Enclosures shall be equipped with a 48-port Security/CCTV Network Switch. One additional 48-port network switch shall be installed at the Box District BRT station Communications Equipment Enclosure for future expansion. A total of five Security/CCTV Network Switches shall be furnished, configured, and installed as part of this contract.

- C.** The Security/CCTV Network Switches shall support PoE-plus (IEEE 802.3at) across all available ports, except uplink ports.
- D.** The Security/CCTV Network Switches shall have a 1-RU form factor.
- E.** The Security/CCTV Network Switches shall each be equipped with an optional two-port 10GbE SFP module uplink.
- F.** Each Security/CCTV Network Switch shall be equipped with optional Dual Power Supply for supporting a combined power budget of 750W.
- G.** The Security/CCTV Network Switches shall include all necessary edge/core network licenses.
- H.** The Security/CCTV Network Switches shall be Extreme Networks Summit X460 model number Summit X460-48p, each equipped with the following options/accessories:
  - 1. Extreme Networks XGM3S-2sf/module
  - 2. Extreme Networks Summit 750W PoE AC PSU
  - 3. Extreme Networks Summit X460 Core License
  - 4. Two(2) Extreme Networks 10GBASE-LR SFP+
  - 5. Twenty(20) Extreme Networks 100BASE-FX SFP
- I.** The Security/CCTV network switches shall be installed in two-post equipment racks at each of the four Communications Equipment Enclosures as depicted in the Contract Drawings. The Contractor shall provide all necessary hardware and appurtenances for a complete rack-mount installation.
- J.** The MBTA shall configure the Security/CCTV network switches prior to installation by the contractor. The contractor shall deliver the Security/CCTV network switches to the MBTA, and coordinate final installation of switches with the MBTA after they have been configured.

## **2.6 FIXED IP CCTV STATION CAMERA**

- A.** The Fixed IP CCTV Station Camera to be provided under this Section shall meet or exceed the following requirements:
  - 1. The Fixed IP Camera shall be certified by the manufacturer to be fully compatible with the Network Video Recorder specified elsewhere in the section.
  - 2. The Fixed IP Camera shall be of a day/night (color/B&W) type with automatically removable infrared cut filter for viewing scenes at low light levels.
  - 3. The Fixed IP Camera shall output multiple video streams using different codecs simultaneously.
  - 4. The Fixed IP Camera shall stream both H.264 and MJPEG, minimum.
  - 5. The Fixed IP Camera shall include a Web User Interface.

6. The Fixed IP Camera shall support bi-directional audio.
7. The Fixed IP Camera shall be ONVIF conformant.
8. The Fixed IP Camera shall accept SD, SDHC, and SDXC cards for recording video on the camera.
9. The Fixed IP Camera shall have a Wide Dynamic Range to compensate for a wide range of ambient lighting conditions within a camera's field of view. The dynamic range shall be a minimum of 120dB.
10. The Contractor shall provide and install all required camera mounting brackets, adapters and associated hardware to mount the Fixed IP Cameras at the location(s) shown on the Contract Drawings.
11. The Fixed IP Camera shall accept a minimum of 1/4" bolts for mounting.
12. The Fixed IP Camera shall have a 3/4" threaded knockout for conduit attachments which shall be used for all connections to the Fixed IP Camera.
13. The Fixed IP Camera shall stream 30 FPS at 1280 x 960 resolution with H.264 encoding.
14. The Fixed IP Camera shall simultaneously stream two separate 15 FPS multicast streams at 1280 x 960 with H.264 encoding.
15. General Construction
  - a. Impact resistant housing, IK10, minimum
  - b. Clear polycarbonate dome
  - c. Tamper and impact resistant CCTV Camera assembly
16. Electrical
  - a. RJ-45 connector for 100Base-TX Ethernet
  - b. Input voltage: PoE (IEEE 802.3af) Class 0, 12.95 watts at camera; maximum
17. Camera and heater shall be fully operational to the Operating Temperature listed elsewhere in this specification on IEEE 802.3af PoE.
18. Imaging System
  - a. Iris Automatic iris control
  - b. Imaging Sensor: 1/3" Progressive Scan CMOS
  - c. Image Resolution: 1280 x 960 @ 30 FPS, minimum
  - d. Focus: Remote focus and zoom
  - e. Varifocal Lens: 3.3-12mm vari-focal @ F1.4, maximum
19. Minimum Illumination (No Image Enhancement, AGC On, 30 FPS)
  - a. Color: 0.15 lux @ F1.4
  - b. Black & White: 0.02 lux @ F1.2
20. Camera Angle Adjustment
  - a. Panning Range: 360°
  - b. Tilting Range: 170°, minimum

21. The Fixed IP Camera assembly shall meet or exceed the following environmental requirements:
  - a. Operating Temperature -40°F to +131°F
  - b. Environmental Rating IP66
22. Networking Requirements:
  - a. The Fixed IP Camera shall include Unicast and Multicast streaming.
  - b. The Fixed IP Camera shall support the following protocols: TCP/IP, UDP/IP, IPv4, IPv6, HTTP, HTTPS, Unicast, Multicast (IGMP), UPnP, DNS, DHCP, ARP, FTP, RTP, and NTP.
  - c. The Fixed IP Camera shall be password protected.
  - d. The Fixed IP Camera shall be fully compatible with the Ethernet Switch, Network Video Recorder, and VidSys.
- B. The Contractor shall be responsible for all Fixed IP Camera setting adjustments to be configured for the location and application. Fixed IP Camera adjustments shall include (but not be limited to) brightness, contrast, saturation, zoom level, focus, back light compensation, wide dynamic range, frame rate, and compression.

## **2.7 FIXED IP CCTV BUSWAY CAMERA**

- A. The Fixed IP CCTV Busway Camera to be provided under this Section shall meet or exceed the following requirements:
  1. The Fixed IP Camera shall be certified by the manufacturer to be fully compatible with the Network Video Recorder specified elsewhere in the section.
  2. The Fixed IP Camera shall be of a day/night (color/B&W) type with automatically removable infrared cut filter for viewing scenes at low light levels.
  3. The Fixed IP Camera shall output multiple video streams using different codecs simultaneously.
  4. The Fixed IP Camera shall stream both H.264 and MJPEG, minimum.
  5. The Fixed IP Camera shall include a Web User Interface.
  6. The Fixed IP Camera shall support bi-directional audio.
  7. The Fixed IP Camera shall be ONVIF conformant.
  8. The Fixed IP Camera shall accept SD, SDHC, and SDXC cards for recording video on the camera.
  9. The Fixed IP Camera shall have a Wide Dynamic Range to compensate for a wide range of ambient lighting conditions within a camera's field of view. The dynamic range shall be a minimum of 120dB.
  10. The Contractor shall provide and install all required camera mounting brackets, adapters and associated hardware to mount the Fixed IP Cameras at the location(s) shown on the Contract Drawings.
  11. The Fixed IP Camera shall accept a minimum of ¼" bolts for mounting.

12. The Fixed IP Camera shall have a ¾" threaded knockout for conduit attachments which shall be used for all connections to the Fixed IP Camera.
  13. The Fixed IP Camera shall stream 12 FPS at 2952 x 1944 resolution with H.264 encoding.
  14. The Fixed IP Camera shall simultaneously stream two separate 15 FPS multicast streams at 1280 x 960 with H.264 encoding.
  15. General Construction
    - a. Impact resistant housing, IK10, minimum
    - b. Clear polycarbonate dome
    - c. Tamper and impact resistant CCTV Camera assembly
  16. Electrical
    - a. RJ-45 connector for 100Base-TX Ethernet
    - b. Input voltage: PoE (IEEE 802.3af) Class 0, 12.95 watts at camera; maximum
  17. Camera and heater shall be fully operational to the Operating Temperature listed elsewhere in this specification on IEEE 802.3af PoE.
  18. Imaging System
    - a. Iris Automatic iris control
    - b. Imaging Sensor: 1/3.2" Progressive Scan CMOS
    - c. Image Resolution: 1600 x 1200 @ 30 FPS, minimum
    - d. Focus: Remote focus and zoom
    - e. Varifocal Lens: 3-9 mm vari-focal @ F1.2, maximum
  19. Minimum Illumination (No Image Enhancement, AGC On, 30 FPS)
    - a. Color: 0.2 lux @ F1.2
    - b. Black & White: 0.04 lux @ F1.2
  20. Camera Angle Adjustment
    - a. Panning Range: 360°
    - b. Tilting Range: 160°, minimum
  21. The Fixed IP Camera assembly shall meet or exceed the following environmental requirements:
    - a. Operating Temperature -40°F to +131°F
    - b. Environmental Rating IP66
  22. Networking Requirements:
    - a. The Fixed IP Camera shall include Unicast and Multicast streaming.
    - b. The Fixed IP Camera shall support the following protocols: TCP/IP, UDP/IP, IPv4, IPv6, HTTP, HTTPS, Unicast, Multicast (IGMP), UPnP, DNS, DHCP, ARP, FTP, RTP, and NTP.
    - c. The Fixed IP Camera shall be password protected.
    - d. The Fixed IP Camera shall be fully compatible with the Ethernet Switch, Network Video Recorder, and VidSys.
- B. The Contractor shall be responsible for all Fixed IP Camera setting adjustments to be configured for the location and application. Fixed IP Camera adjustments shall include

(but not be limited to) brightness, contrast, saturation, zoom level, focus, back light compensation, wide dynamic range, frame rate, and compression.

## **2.8 FIBER-OPTIC MEDIA CONVERTER**

- A.** The Fiber-Optic Media Converter shall convert Ethernet signals from each pole mounted camera for transmission over fiber-optic cable.
- B.** The Fiber-Optic Media Converter shall support 100Mbit (minimum) bit rate for each camera feed on the system.
- C.** The Fiber-Optic Media Converter shall be equipped with two RJ45 connectors and two SFP connectors. One RJ45 connector shall be available for local connection/monitoring by service personnel.
- D.** The Fiber-Optic Media Converter shall have the following characteristics:
  - 1. 12-14 VDC power supply – 4W (maximum)
  - 2. Power and network LED indicators
  - 3. DIN rail mount
  - 4. Storage/Operating Conditions: -40 to 167 deg F, 10-85% RH (non-condensing)
  - 5. Max Dimensions: 6” x 4” x 2”
- E.** The Fiber-Optic Media Converter shall be compatible with the proposed CCTV Cameras, SFP modules, and Ethernet switch.
- F.** The Fiber-Optic Media Converters shall be installed inside each of the pole-mounted equipment enclosures at each busway pole-mounted CCTV camera location as depicted on the Contract Drawings.

## **2.9 PoE MIDSPAN POWER INJECTOR**

- A.** The PoE Midspan Power Injectors shall provide camera power for each busway pole-mounted CCTV camera.
- B.** The PoE Midspan Power Injectors shall have the following characteristics:
  - 1. Output 15W PoE power per port (minimum), IEEE 802.3af compliant
  - 2. 100 Mbps throughput per port
  - 3. Input power 100-240 VAC, 47-63 Hz, .5Amps (maximum)
  - 4. Operating Temperature: -20 to 140 deg F
  - 5. Dimensions: 2” x 3” x 6” (maximum)
- C.** The PoE Midspan Power Injectors shall be compatible with the proposed CCTV Cameras and Fiber-Optic Media Converters.

- D. PoE Midspan Power Injectors shall be installed inside each of the pole-mounted equipment enclosures at each busway pole-mounted CCTV camera location as depicted on the Contract Drawings.

## **2.10 POLE MOUNTED CCTV EQUIPMENT ENCLOSURES**

- A. The Pole Mounted CCTV Equipment Enclosures shall house the power supplies, PoE Midspan Power Injectors, Fiber Optic Media Converters, termination blocks, and associated power supplies for each busway pole-mounted CCTV camera.
- B. The Pole Mounted CCTV Equipment Enclosures shall be IP66, NEMA 4X, and IK10 rated.
- C. The Pole Mounted CCTV Equipment Enclosures shall have the following characteristics:
  - 1. Polycarbonate construction
  - 2. Operating Conditions: -40 to 167 deg F
  - 3. Weight: 9 lbs. (maximum)
  - 4. Interior Dimensions: 9" x 11" x 4" (minimum)
- D. The Pole Mounted CCTV Equipment Enclosures shall include all mounting hardware necessary for installation on busway lighting poles.
- E. The Pole Mounted CCTV Equipment Enclosures shall include a tamper switch which shall be connected to each corresponding CCTV camera input to detect and notify MBTA personnel that the enclosure has been opened. This tamper condition shall be programmed into the VidSys PSIM as a separate alarm input.

## **2.11 ENVIRONMENTAL MONITORING APPLIANCE**

- A. The Contractor shall install and configure one Environmental Monitoring Appliance at each of the four communication equipment enclosures included in the project.
- B. The Environmental Monitoring Appliance shall utilize SNMP, Email, SMS, and a web page to report sensor information and alarm conditions.
- C. The Environmental Monitoring Appliance shall include a MIB file allowing integration into SNMP capable devices.
- D. The Contractor shall alert the MBTA IT Department when the device comes online so that it may be established in the MBTA's SNMP management platform.
- E. The Environmental Monitoring Appliance shall be fully licensed for all features.
- F. The Environmental Monitoring Appliance shall meet or exceed the following specifications:
  - 1. Dimensions: 4" x 2" x 1.5", max
  - 2. Power: 120 VAC and POE



- |    |                        |                              |
|----|------------------------|------------------------------|
| 3. | Networking:            | 10/100 BaseTX Ethernet, RJ45 |
| 4. | Built-in Sensors:      |                              |
|    | 1) Temperature range:  | -67°F to 257°F               |
|    | 2) Humidity range:     | 5 to 95%                     |
| 5. | Operating Temperature: | -40 °F to 185 °F             |
| 6. | Operating Humidity:    | 5% to 85%                    |
| 7. | Digital Sensor Ports:  | 1                            |
| 8. | Dry contact inputs:    | 1                            |

## **2.12 POWER OVER ETHERNET (POE) SURGE SUPPRESSOR**

- A. Each Fixed IP CCTV Station Camera CAT6 cable shall be protected by a PoE Surge Suppressor located in the communications equipment enclosure for its corresponding station.
- B. PoE Surge Suppressors shall be used to protect network equipment from surges and shall be installed on all outdoor cameras. The PoE Surge Suppressor shall not have any effect on the data and power transmissions and shall protect all lines in the Category 6 cable.
- C. PoE Surge Suppressors shall be installed in rack mount chassis whenever the connected switch is rack mounted, and can be individually attached to the back panel in a neat manner in a wall mount cabinet.
- D. The PoE Surge Suppressors shall automatically reset after a surge event.
- E. PoE Surge Suppressors shall meet or exceed the following specifications:
 

1.	Dimensions:	4.5" x 2" x 1.5", max
2.	Mounting:	Panel and Rack depending on location
3.	Clamping Voltage:	60 Volts
4.	Response Time:	Less than 5 ns
5.	Compatible Ethernet Speeds:	10/100Base-T
6.	Approvals:	UL 497B

## **2.13 LOW SMOKE ZERO HALOGEN (LSZH) CATEGORY 6 (CAT6) CABLE**

- A. All CAT6 network cable shall be suitable for outdoor, aerial lashing, and buried conduit applications to support communications of Megapixel and IP CCTV outdoor camera installations.
- B. All CAT6 network cabling and connections shall be labeled as shown on approved shop drawings for type, location and service.
- C. All CAT6 cables and components installed shall comply with the following:

1. All CAT6 network cabling systems shall have EIA/TIA 568B Series standard pin/pair termination assignment. All conductors provided shall be properly and consistently terminated at both ends throughout the entire system.
2. ANSI/TIA/EIA-568-B most current revision
3. IEEE 802.3af DTE Power and MDI Verified
4. IEEE 802.3ab Gigabit Ethernet Verified
5. ETL Verified
6. FCC part 68.5, subpart F compliant
7. ISO 11801 2nd Edition, Class E Compliant

D. Cable Physical Characteristics:

- |                           |                                       |
|---------------------------|---------------------------------------|
| 1. Jacket:                | Low Smoke Zero Halogen                |
| 2. Jacket Color:          | Green                                 |
| 3. Insulation:            | Polyolefin                            |
| 4. Conductors:            | #24 AWG Solid Bare Copper, or greater |
| 5. Composition:           | 4 Pair, UTP with Core Separator       |
| 6. Operating Temperature: | -4 °F to 140 °F                       |
| 7. Cable O.D. (Max):      | 0.3 Inches                            |
| 8. Voltage Rating:        | 300 Volts RMS                         |
| 9. Flame Tests:           | IEEE 1202/FT4 and UL1685              |

## **2.14 CATEGORY 6 (CAT6) PATCH CABLES AND WORKSTATION CORDS**

- A. Patch cables and workstation cords shall be factory pre-connectorized, TIA/EIA Category 6 Extended Frequency (UL Category 6E), 4 UTP, 8-position modular jack, utilizing stranded conductors. All patch cables shall be LSZH and meet the flame test requirements of Low Smoke Zero Halogen Category 6 Cable.
- B. Patch cables and workstation cords shall be able to withstand at least a minimum of 2,000 jack mating cycles without any transmission degradation.
- C. Workstation cords shall be a minimum of 15-feet in length.

## **2.15 CAT6 RJ45 END CONNECTORS**

- A. All RJ45 End Connectors shall be in compliance with the TIA-568B standards.
- B. All RJ45 End Connectors shall be designed for CAT6 UTP.

- C. All RJ45 End Connectors shall be IEC-60603-7-4 compliant.
- D. All RJ45 End Connectors shall accommodate #23 AWG thru #26 AWG conductors.
- E. All RJ45 End Connectors shall have 50μ gold-plated contacts.
- F. All RJ45 End Connectors shall have a plastic housing and a plastic insert with stepped entry for individual wires.
- G. All RJ45 End Connectors shall be RoHS compliant.
- H. All RJ45 End Connectors shall be specifically manufactured for the UTP cable to which they will attach.
- I. All RJ-45 End Connectors shall have an operating temperature of -40 to 158 °F.
- J. All RJ-45 End Connectors shall have a minimum life cycle of 1,000 mating cycles.
- K. All RJ-45 End Connectors shall also be installed with a red strain relief boot designed to work with the connector and cable being used.

#### **2.16 48 PORT UTP CATEGORY 6 PATCH PANEL**

- A. The 48 Port UTP Category 6 (CAT6) Patch Panel shall meet or exceed the following specification:
  - 1. 1U EIA standard 19-inch cabinet
  - 2. 110 terminations in the rear of the panel
  - 3. TIA/EIA-T568-B.2 CAT6 connecting hardware specifications
  - 4. RJ45 8P8C modular jacks
  - 5. 50μ gold-plated contacts
  - 6. Black electrostatic powder-coated steel
  - 7. Accommodates top, bottom or side cable entry
  - 8. Write-on designation label with clear holder
  - 9. UL Certified

#### **2.17 RACK MOUNT UNINTERRUPTIBLE POWER SUPPLY**

- A. The Uninterruptible Power Supply shall be connected to the equipment as indicated on the Contract drawings.

- B. The Uninterruptible Power Supply shall provide backup power for all connected equipment at each identified equipment rack and equipment enclosure location as shown on the Contract Drawings.
  - 1. The UPS shall be sized per the connected equipment at each site to provide 100% of the backup power required to power all devices at full load for 15 Minutes.
  - 2. Full load shall include all Power Over Ethernet (PoE) Switches as if each were fully populated with all PoE ports connected to CCTV cameras.
- C. The UPS shall meet or exceed the following requirements:
  - 1. Shall be designed for 19" equipment rack mounting
  - 2. Shall have an input of 120 – 208 VAC and an output of 120 VAC
  - 3. Shall include hot swappable batteries
- D. The UPS shall include an integrated SNMP power management system to monitor the equipment and to provide status and alarm conditions. The Contractor shall program the power management system and connect the UPS to the network to provide status monitoring of the UPS and associated battery bank utilizing the MBTA monitoring system. The UPS monitoring shall include the following status measurements and alarms at a minimum:
  - 1. Loss of utility AC power
  - 2. Restoration of utility AC power
  - 3. Low battery
  - 4. UPS fault
  - 5. Battery Failure
- E. The Contractor shall provide and install ancillary UPS power distribution equipment as required by Code and MBTA specifications and practices. This shall also include all materials and cabling to provide a complete installation, and shall include:
  - 1. Two (2) full vertical height AC power distribution strips in each equipment rack.

## **2.18 TWO-POST EQUIPMENT RACKS**

- A. Three(3) Two-Post Equipment Racks shall be installed in each of the four Communications Equipment Enclosures as depicted in the Contract Drawings.
- B. The Two-Post Equipment Racks shall be levelled and fastened to the floor according to the manufacturer's installation instructions.
- C. The Two-Post Rack installation shall meet current seismic standards and requirements.
- D. The Two-Post Rack shall have the following characteristics:

1. Black Finish
2. 72" in height, with a 38 RU capacity.
3. 10-32 threaded, with numbered spaces.
4. Sturdy steel construction (11-gauge minimum)
5. Each Two-Post Rack shall include a minimum of fifty rack screws.
6. UL Listed

## **2.19 VERTICAL POWER DISTRIBUTION UNITS**

- A. Vertical Power Distribution Units shall be used to power all equipment in open frame equipment racks at the station.
- B. Vertical Power Distribution Units shall take two (2) 20 Amp circuits as input and shall have alternating color coded outlets indicating which circuit it is being fed from.
- C. Vertical Power Distribution Units shall have a built-in ammeter for each circuit and an LCD display for each circuit indicating circuit utilization in Amperes.
- D. Contractor shall label Vertical Power Distribution Units indicating the panel that is feeding it.
- E. The Contractor shall provide a junction box with locking outlet at the base of the open frame racks for connection to the Vertical Power Distribution Units.
- F. Vertical Power Distribution Units shall meet or exceed the following specifications:
  1. Length: 71"
  2. Width: 3", max
  3. Height: 1.5", max
  4. RMU: 0
  5. Input Plug Type: NEMA L5-20P
  6. Input Voltage: 120VAC, single phase
  7. Output Plugs: 32 (16 from each 20 Amp input, color coded)
  8. Output Plug Type: NEMA 5-15/20R
  9. Output Voltage: 120VAC
  10. Certifications: UL-60950-1

## **2.20 NETWORK VIDEO RECORDERS (NVRs)**

- A. The MBTA currently has installed Genetec and Geutebrück Video Management Systems (VMS). The Contractor shall provide NVRs that are fully compatible and cross-functional with the existing MBTA VMSs. In the event that the Contractor chooses to propose NVR hardware and/or software that is not currently integrated with existing MBTA systems, the contractor shall be required to demonstrate seamless compatibility and operation of the proposed systems with the existing MBTA hardware and software. Furthermore, the Contractor shall be required to provide letters from the system manufacturers, certifying that the integration of the components has been tested, verified, and fully documented by each respective manufacturer. This includes (but is not limited to) integration with the VidSys PSIM platform.

- B. The NVR software shall be installed on the Existing Pivot3 CCTV Video Server Clusters and shall record all images from CCTV Cameras and CCTV Encoders to the CCTV Video Server Clusters, and it shall connect viewing clients to live or recorded streams.
- C. The NVR shall be a part of a VMS and will be managed by management servers as necessary. The NVR shall appear to Operators to be seamlessly integrated with the entire CCTV System.
- D. The Contractor is to provide all software and licensing necessary for the connection and recording of all Cameras and Encoders to the NVR/VMS.
- E. The Contractor is to provide all software and licensing necessary for all installed CCTV Cameras, Encoders and NVR instances and the connection of those items to the VidSys Server and Clients.
- F. The Contractor shall provide the operating system licenses for the operating system recommended by the NVR/VMS manufacturer if other than Windows Server 2008 Standard.
- G. The NVR shall be configured to record all channels on motion only. It shall also record the 30 seconds prior to the beginning of motion detection and 30 seconds after all motion has ended. The motion recording shall be set up on the camera, and shall use the CCTV camera's built-in motion detection features; the motion detection shall not occur on the CCTV Video Server or any separate video analytics server. The MBTA may select certain critical channels to be on 24 hour recording.
- H. The amount of days of video retention for video from a specific camera shall be selectable in the NVR software so that different cameras on the same NVR can have different storage time lengths.
- I. The NVR shall allow connections to video analytics software packages and shall use the metadata to trigger alarms.
- J. The NVR manufacturer shall guarantee backward compatibility for three software versions.
- K. The NVR shall be configured to receive all tamper alarms from the CCTV camera and pass them to VidSys. The tamper detection shall be set up on the camera, and shall use the CCTV camera's built-in tamper detection features.
- L. If the NVR/VMS chosen by the Contractor is not a platform currently installed by the MBTA, the Contractor shall also furnish and install the following:
  - 1. If the system requires separate management servers, furnish and install two redundant enterprise level management servers, at MBTA locations to be provided to the Contractor, complete with all software and licenses necessary.
    - a. Management Server Hardware Specifications:
      - 1) Processor: (2) Quad Core Xeon E5620
      - 2) Memory: 24GB, 6x4GB, 1333MHz
      - 3) Storage: (3) 1TB, 7.2K RPM, Hot Swap, SATA or SAS
      - 4) Networking: (2) Dual Port Gigabit NIC, teamed for redundancy
      - 5) Power Supply: Redundant
    - b. Contractor to provide operating system as recommended by the NVR software manufacturer.

2. The Contractor shall furnish and install any VidSys connector and connector licenses needed for seamless integration.
  3. The Contractor shall furnish and install any software licenses necessary to achieve the same level of functionality existing in the current NVR systems and to achieve the functionality described in these specifications.
  4. The Contractor shall furnish and install any SDK/Client licenses necessary for all MBTA VidSys Clients to view all cameras.
  5. Any other hardware and/or software components necessary for the complete and redundant functioning of the VMS system chosen.
- M. The NVR Software shall be installed on the CCTV Video Servers and store video streams to the CCTV iSCSI Storage to create the NVR solution. The CCTV Video Server shall not software limit the number of cameras that can be recorded and shall have a 240Mb/s recording throughput with the NVR Software. The Contractor shall provide servers sufficient for all input and output of video for the existing and new IP CCTV and analog cameras at the station.
- N. If the primary management server fails or loses connectivity, the secondary shall immediately take over the duties of the primary server. Upon reestablishment of connection by the primary server, the secondary shall resynchronize with the primary and it shall be restored to control.
- O. The NVR shall pass any tamper alarms, camera covering, camera tamper, motion, analytic, and all other alarms to the VidSys system for display, statistics and/or use in alarming algorithms.
- P. The NVR shall store video from digital video sources in MPEG4, MJPEG, and H.264 codecs. H.264 shall be utilized in this project. The video shall be accessible in near real-time.
- Q. All NVRs shall have their time synchronized with Network Time Protocol. The time on all NVRs shall be synchronized with the management servers within the system and shall update a minimum of 3 times a day and shall not have an effect on network traffic.
- R. Live streams sent from the CCTV Cameras shall not be processed through an NVR. Clients that request a live stream shall simply be connected by the VMS to the live view multicast stream from the CCTV Camera.
- S. The following are redundancy and failover feature requirements of the NVR/VMS that are to be configured by the Contractor.
1. The VMS shall be configured so that the CCTV Cameras are seamlessly recorded to multiple NVRs via a single multicast stream from the camera.
    - a. If one of the NVRs fails, it shall not interfere with the recording to the second NVR and the VMS shall keep track of the location of recorded video for seamless access to the recorded streams from the VMS, VidSys, or any other integrated client.
  2. The VMS shall allow for an unlimited number of management servers to be placed throughout the network to take over in the case of any network failures that leave portions of the network detached from the primary server. The local management server shall manage the systems it has connectivity to until the

network connection to the primary is reestablished, at which time it shall resynchronize with the primary server and relinquish control.

T. Product Description

1. The Video Management System software shall be a fully open architecture distributed solution, designed for multi-site and multiple server installations requiring 24/7 surveillance with support for devices from different vendors and fully scalable for future growth. The Video Management System shall offer centralized management of all devices, NVRs, servers and users and shall utilize a flexible rule-based system driven by schedules and events.
2. The Video Management System software shall not place limits on the number of simultaneous video feeds, or on the number of NVRs to be connected to the VMS.
3. The Video Management System shall incorporate fully integrated video Matrix switching functionality for distributed viewing of any camera in the system from any computer with the Client Viewer and/or Monitor application installed.
4. The Video Management System shall include a Software Development Kit (SDK) that shall permit the integrating of the system with 3rd-party software. The SDK shall enable the user to retrieve live and recorded video in several ways:
  - a. In raw data format,
  - b. As a window to be resized and shown embedded in another application.
  - c. Create plug-in components for the Video Client Software.
  - d. Control the operation of Matrix Monitor.
  - e. Upon receipt of alarm and event information
5. The SDK shall allow for the video to be displayed in VidSys without video quality issues in any version of Internet Explorer supported by VidSys. The CCTV Camera video quality shall be the same or better in VidSys as in the native VMS application and as in the camera web page.
6. All on-camera Video Analytics behavior detection functionality shall be fully operational in the event that the camera is disconnected from the security network or the primary and backup servers are disconnected from the security network. All alarms generated while disconnected from the network shall be stored and then delivered to the appropriate recipient when the network connection is restored.
7. The Video Management System shall include a stand-alone Viewer application to be included with video exported from the Client Viewer application. The Viewer application shall allow recipients of the video to browse and playback the exported video without installing separate software on their computers.
8. The Video Management System shall also allow the video to be exported via SDK connection or native client application in an AVI or ASF format that is playable in Windows Media Player and VLC media player without the manual installation of any codecs.
9. The video management system shall allow for recorded camera feeds to be viewed at reduced frame rates based on user privileges level to manage viewing bandwidth.
10. The Video Management System shall provide a unique loss of video alarm from each camera connected to the system.

U. Video Administration Software



1. The Video Administration Software shall provide a feature-rich administration client for system configuration and day-to-day administration of the system.
2. The Video Administration Software shall be installed on the VidSys Client Workstations dictated by the MBTA, with access via Administrator privileges.
3. The Video Administration Software Graphic User Interface (GUI) shall typically consist of three or four panes. The panes shall be dynamic and change depending on the task.

V. Management Servers

1. The Management Server shall store the system's configuration in a relational database, either on the management server computer or on a SQL Server on the network.
2. The Management Server shall manage all user authentication and user rights.
3. The SQL Server shall store all of the system settings created by the Video Administration Software.
4. The Management Server shall maintain a continuous log of server status messages accessed from the status Icon in the system tray.

W. Device Monitoring

1. The system shall monitor the operational status of all devices connected to the system in normal and alarmed states:
  - a. All network devices shall be monitored as to the current status.
  - b. All cameras shall be monitored to verify that they are functional and streaming video and an alarm shall be displayed upon loss of video or signal transmission.

## 2.21 POWER OVER ETHERNET (POE) OVER CAT6 EXTENDERS

- A. Power over Ethernet (PoE) over CAT6 Extenders shall carry 802.3af and 802.3at power to and data to and from the camera through CAT6 cable while also extending the signal and power transmission distances. The PoE over CAT6 Extenders shall require no power at the camera location. The PoE over CAT6 Extenders shall use one powered (PoE and/or additional power supply) unit near the switch and one unit in the back box of the camera or a junction box located nearby.
- B. PoE over CAT6 Extender Units shall meet or exceed the following specifications:
  1. Dimensions: Less than 4.7"x1.5"x1"
  2. Weight: Less than 0.5 lb.
  3. Mounting: Panel or DIN Rail
  4. Operating Temp: -40°C to +70°C
  5. Relative Humidity: 0 to 85% non-condensing
  6. Ethernet Interface: 10/100Base-T

- |     |                          |  |
|-----|--------------------------|--|
| 7.  | Operating Power:         | Shall pass PoE from the switch and shall have optional power supply to increase PoE distance. Include additional power supply as needed and when powering a PTZ camera. Only the near switch unit shall require power. |
| 8.  | Transmission Distance:   | 3,280' on CAT6 with a minimum of 10Base-T and 15Watts of power with additional power supply (5 Watts without additional power supply). 100 Base-T up to 2,700' from the source.  |
| 9.  | Connectors:              | Ethernet: RJ45<br>Extended Ethernet: RJ45<br>Operating Power: Detachable Screw Terminal  |
| 10. | Standards Compatibility: | IEEE 802.3af PoE IEEE<br>802.3at PoE<br>RFC: 768 UDP, 2068 HTTP, 793 TCP, 791 IP, 1783<br>TFTP, 894 IP over Ethernet.  |
| 11. | RFC:                     | 2544 TCP/IP Packet Transmission  |

## **2.22 SPARE PARTS**

- A. As described in 01010 SUMMARY OF WORK.

## **PART 3 - EXECUTION**

### **3.1 GENERAL**

- A. Installation of all CCTV System shall be in accordance with manufacturer's recommendations, approved shop drawings, and as shown on the Contract Drawings.
- B. All systems and components taken out of service under this contract shall be turned over to the MBTA to be placed in spare parts inventory. Accompanying all turned over equipment shall be a status report of the condition of the device.
- C. All wiring shall be neatly installed and wire ways shall be utilized wherever possible. All wiring shall be identified at both ends by wire markers.
- D. Furnish and install a complete and operable CCTV System.
- E. The Contractor shall be responsible for system start-up, testing and network testing; installation of required interconnections for a fully functional system.
- F. The Contractor shall be responsible for Incidentals and appurtenances necessary to complete the work as specified herein and as shown on the Contract Drawings.

- G. The Contractor shall program all cameras in-house. The Contractor shall not order equipment already addressed, as network IP addresses and the MBTA's IP schema is security sensitive information that shall not be disseminated.
- H. Contractor shall provide one paper set of as-built drawings for each location. Contractor shall deliver one Mylar set to 500 Arborway and one copy on Compact Disk in the latest version of AutoCAD.

### **3.2 INSTALLATION**

- A. Install CCTV cameras in locations with the orientations as approved on the Contract Drawings. All conduits to each device shall be properly sized GRSC.
- B. Install supporting equipment in cabinets and on racks, in the station communication room as shown on the Contract Drawings.
- C. Cabling to all CCTV cameras shall be CAT6, and cable lengths, including patch cords, shall not exceed 328 feet.
- D. No Ethernet connected device shall be installed until its cabling is properly labeled.
  - 1. The device end of each Category 5, 5e, or 6 cable shall be labeled indicating the originating rack or cabinet.
  - 2. The switch end of each Category 5, 5e, or 6 cable shall be punched down to a new patch panel and shall be labeled with the device name of the attached device. The patch panel shall also be labeled with the attached device.
  - 3. Fiber Optic Patch Panels shall be labeled with the room or cabinet that is at the other end, and the Patch Panel labels shall all be filled out and indicate the device on the opposite end or that the strand is spare.
- E. The Contractor shall label each CCTV component with a label containing the following items, the Contractor shall submit an example label to the MBTA for approval prior to labeling CCTV components:
  - 1. 'MBTA'
  - 2. The three letter location designation
  - 3. The camera number from the Contract Drawings
  - 4. The device ID
  - 5. A QR code of the camera label information
- F. All labels used shall be machine printed yellow weatherproof labels and withstand rain, sleet, snow, dust, and temperatures of -20°F to 160°F. Font and font size shall be approved by the MBTA.

### **3.3 TESTING**

- A. Conduct electrical tests to demonstrate compliance with this Specification and with manufacturer's recommended test procedures as approved by the Engineer.
- B. The Contractor shall supply all test equipment and software for all system tests. Test equipment shall have been calibrated within nine months of test.
- C. CAT5e and CAT6 cable shall be tested after termination to ensure that the cable was not damaged during pulling and that it was properly terminated. The Engineer reserves the right to attend or send a representative to any cable testing that is performed.

- D. A Wiremap test shall be performed on all CAT5e and CAT6 cables with a commercial off the shelf wiremap tester. The wiremap test shall ensure continuity of wires, absence of shorts, grounding, or any other wire pulling or termination problems or errors.
1. Specification sheets of the wiremap tester and test procedure shall be submitted to the Engineer for approval prior to the beginning of testing.
  2. All tests shall be recorded with a description of which cable is being tested, a pass or fail, the reason for failure, the corrective action taken, the date, the time, and the technicians performing the test. Tests shall be re-run after the corrective action is taken. The test reports shall be submitted to the Engineer for approval.
- E. An Ethernet bandwidth test shall also be performed on all CAT5e and CAT6 cables with commercial off the shelf handheld Ethernet bandwidth testers that perform RFC 2544 compliant tests at one Gigabit. The Ethernet bandwidth tester shall also be capable of saving test reports to internal or removable storage to be printed or made into a PDF. The test setup shall use one tester on each end of the cable and shall test bi-directionally.
1. Specification sheets of the Ethernet bandwidth testers and test procedure shall be submitted to the Engineer for approval prior to the beginning of any testing.
  2. All tests shall be recorded with a description of which cable is being tested, the cable length as measured by the Ethernet bandwidth testers, the measured bandwidth, the Bit Error Rate, the date, the time, and the technicians performing the test. The test reports shall be submitted to the Engineer for review.
- F. The Contractor shall perform an acceptance site walkthrough with a member or members of the MBTA Communications, Security, and Electrical Departments prior to final project acceptance. The Contractor must provide subsequent walkthroughs if issues are found with installation that must be corrected.
- G. After installation is complete, the Contractor shall verify proper operation of all system software control functions and video streams as described herein, to test all functionality of the CCTV System. The Contractor shall develop and submit a test plan for review by the Engineer 30 days prior to testing, the test plan shall contain performance and failure testing of all levels and all components within the system. The test plan shall include integration of the CCTV system into the MBTA Wide Area Network(s). Notify the Engineer a minimum of 14 days in advance of test. Engineer or authorized representative reserves the right to attend and approve testing.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of the Closed Circuit Television System for the BRT Stations and the Busway.

### **END OF SECTION**

## **SECTION 16844**

### **COMMUNICATIONS SYSTEM JUNCTION BOXES**

#### **PART 1 - GENERAL**

##### **1.1 DESCRIPTION**

- A. This Section specifies requirements for furnishing and installing junction boxes for communications cable terminations.
- B. All junction boxes shall be wall mounted type junction boxes constructed of stainless steel (or fiberglass if in proximity to a catenary system) and are to be all cable termination/junction locations as shown on the Contract Drawings, and as approved by the Engineer.
- C. New junction box locations are as shown on the Contract Drawings. Contractor may submit alternate junction boxes locations and mounting arrangements to the Engineer for approval. Care shall be taken with locating enclosures and conduits to ensure that proper clearances are maintained. All junction boxes, permanent and temporary conduits and cabling shall be installed outside of the standard clearance envelope.

##### **1.2 QUALITY ASSURANCE**

- A. Comply with the requirements of Section 01400—Quality Control

##### **1.3 SUBMITTALS**

In accordance with the requirements of Section 01300—Submittals, the Contractor shall submit the following to the Engineer for his approval

- A. Manufacturer's drawings and catalog cuts of junction boxes and all associated mounting hardware;
- B. Detailed/scaled internal junction box layout showing all internal accessories, space for dressing/running wire conductors, methods/materials for securing wiring and components to backboard;
- C. Drawings and procedures for the installation of junction boxes. Detailed mounting drawings/procedures are to be submitted in instances where the typical details do not apply or are modified;
- D. Detailed installation drawings showing method of cabling transition from aerial messenger, from GRS conduit riser(s) and/or trough into junction box.

##### **1.4 DELIVERY, STORAGE AND HANDLING**

- A. Materials shall be protected from damage during delivery, storage and handling.

- B. Damage to material, resulting from improper handling by the shipper or the Contractor shall require the Contractor to replace all damaged material with new material at no additional cost to the Contract.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL**

- A. Where cable junction boxes are equipped with a wooden backboard, it shall be ¾" marine plywood backboard, primed and then painted ANSI 61 gray.

### **2.2 WALL MOUNTED JUNCTION BOXES**

- A. The typical wall mounted junction box shall be NEMA 4X and constructed of stainless steel (or fiberglass if in proximity to the catenary system), as a minimum standard, sized as required so as not to conflict with the train clearance envelope. The junction box shall be provided with a stainless steel hinges and stainless steel padlock hasp and staple sized for standard MBTA padlock.
- B. Wall mounted junction boxes are to be installed at approved locations with stainless steel hardware.
- C. Provide a padlock, keyed alike existing padlocks, for each junction box provided.

## **PART 3 - EXECUTION**

### **3.1 GENERAL**

- A. Communication cable junction boxes shall be installed at the locations shown on the Contract Drawings. Contractor may submit alternate junction boxes locations and mounting methods to the Engineer for approval.
- B. A minimum of 8" of slack shall remain secured within the junction box for each individual conductor.
- C. Wall mounted junction boxes shall be installed plumb and level and shall not interfere with the train clearance envelope.
- D. Conduit entrances into junction boxes shall be via a Myers™ type hub.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of the communications system junction boxes.

## **END OF SECTION**

**SECTION 16876**  
**COMMUNICATIONS GROUNDING OF EQUIPMENT**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. This Section specifies furnishing and installing a grounding system for communication junction boxes and any other wayside equipment or apparatus as hereinafter specified.
- B. The grounding system shall preclude any closed loop grounding arrangement.
- C. Ground connection to the track rails or use of the neutral conductors of the Power Company or AC signal supply system shall not be permitted.
- D. Related work: see Section 16450—Grounding.

**1.2 QUALITY ASSURANCE**

- A. All grounding systems furnished and installed as herein specified shall be inspected and any deficiencies noted shall be corrected. The inspection shall be conducted in conformance with the requirements of the Contractor's Installation Inspection Procedure as approved by the Engineer.
- B. Final tests of the grounding system shall be in conformance with the requirements of Section 16898, Communication System Tests, and any other relevant sections of these Specifications.

**1.3 SUBMITTALS**

- A. In accordance with the requirements of Section 01300—Submittals, the Contractor shall submit an Installation, Inspection and Testing Procedure for grounding of all equipment to the Engineer for approval.

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

- A. Ground rods, clamps, and ground wire shall be as specified in Section 16897, Miscellaneous Components and Products and Section 16450—Grounding

**PART 3 - EXECUTION**

**3.1 EQUIPMENT GROUNDING**

- A. The ground bus in equipment rooms shall be connected with separate insulated No. 6 stranded soft drawn copper wire to the prime signal ground bus.
- B. All insulated ground wires shall have green insulation.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of the communications grounding of equipment.

**END OF SECTION**



## **SECTION 16881**

### **PUBLIC ADDRESS SYSTEM**

#### **PART 1 - GENERAL**

##### **1.1 DESCRIPTION**

- A. This Section specifies furnishing, and installing a complete and operational Public Address and Electronic Sign System (PA/ESS) at four Chelsea Silver Line Gateway BRT stations.
- B. System functionality is based on the specifications given and the information shown on the drawings. Actual system performance shall be measured against design performance criteria.
- C. The Station Public Address System installed under this Station Contract shall receive, amplify, monitor, and distribute (via loudspeakers), voice announcements originating remotely from the Announcement Control System at OCC and Workstations, and locally from four local microphone stations, and Remote Access Terminals.
- D. Station Public Address system shall be configured for a minimum of 8 zones (Mystic Station OB, Mystic Station IB, Downtown Chelsea OB, Downtown Chelsea IB, Box District OB, Box District IB, Eastern Ave. OB, and Eastern Ave IB). Additional zones to be added as specified on the contract drawings.
- E. Zones shall consist of both Variable Message Signs (VMS) and PA Speakers.
- F. Each zone of speakers shall consist of two circuits of alternating speakers A & B. The PA System shall be configured so equipment and wiring failures related to circuit A shall not affect the operation of circuit B. The PA System shall be configured so equipment and wiring failures related to circuit B shall not affect the operation of circuit A. Each circuit shall carry half the speaker load per zone.
- G. The Public Address System installed under this Contract shall fully integrate, interface and work with the ARINC PA/ESS Head End hardware and software system installed at the Operations Control Center (OCC). Including all local station maintenance and diagnostic functions, both local and remote monitoring. The maintenance functions shall include but not be limited to: remote monitoring and configuration of public address Digital Signal Processor (DSP), Public Address power amplifiers, preamplifiers, Station Control Units (SCU), and Electronic Signs.
- H. The Contractor shall be responsible for installing, configuring and testing ARINC's AIM software on each SCU. Installation and testing shall include full integration with the existing AIM PA/ESS Head End system.
- I. The Contractor shall be responsible for configuring the Authority's existing PA/ESS system at the OCC to allow the Authority's personnel to trigger Public Address messages, both visual and audio, to MBTA stations throughout the system.

- J. The transmission from the OCC will be over the MBTA's Wide Area Network. Where the WAN is not available the Contractor will provide T1 lease lines. The Contractor shall be responsible for providing interface connections to and from the designated Main Distribution Frame (MDF) and or the Wide Area Network.
- K. The PA/ESS network exists and uses a combination of TCP/IP, UDP/IP over Ethernet, Voice over Internet protocol (VoIP) and traditional analog lines to deliver PA/ESS messages.
- L. The Station Public Address System shall be a fully integrated system. The system shall use a local SCU configured with AIM PA/ESS software to manage and control all station functions and hardware including microphone page stations and associated queuing, telephone interfaces, distribution of emergency announcements, local announcements, OCC announcements, recorded announcements, pre-recorded and assembled messages, and visual display paging.
- M. The Passenger Station Public Address System shall include an Ambient Noise Analysis System that will automatically change the volume level of the Public Address System dependent on the amount of the ambient noise level at the station.
- N. The system shall interface directly via Ethernet to one or more zones within the passenger station. Provisions shall be made for serial RS-422 communication between signs within each zone. Signs within a zone shall consist of double-faced 4-line electronic signs. Mounting of the electronic signs shall be as indicated on the contract drawings and per manufacturer's recommendations. Two line signs shall consist of 32 LED high x 320 LED long. Cable interconnect shall consist of shielded category 5 or better wiring. The Contractor shall provide the appropriate Ethernet to Serial Adapters necessary for communication to each Sign.
- O. Designated Passenger Station Systems shall provide telephone access into the OCC Announcement Control System, which shall allow remote announcements to various Passenger Station PA Systems or groups of Passenger Station Systems via a secure access pass-code.
- P. The system shall be capable of distributing data and audio from the OCC to local audio zones and visual displays within the passenger station. The system shall have the capability to send and receive announcements to and from other passenger stations.
- Q. The system shall be capable of monitoring and configuring local PA equipment and PA/ESS equipment installed at other passenger stations.
- R. All Public address equipment installed under this contract shall be connected and monitored from the PA/ESS Head End at the OCC.

## **1.2 PUBLIC ADDRESS HARDWARE PROFILE**

- A. The Contractor shall install all equipment, materials, and cables required to support the station PA/ESS. Installation shall be in accordance with all Contract requirements, approved drawings, and custom commercial practices. Prior to delivery of any equipment on MBTA property, Public Address equipment shall be racked and staged in cabinets and fully tested as an integrated unit. Testing shall include microphone inputs, ambient level microphone control, zone control, electronic sign messaging, audio outputs, system diagnostics utilizing Ethernet

connectivity to amplifier, SCU, DSP, and electronic signs, remote monitoring, and full AIM software functionality. Contractor shall provide certification of all testing prior to installation at the passenger station.

### **1.3 AUDIBILITY/INTELLIGIBILITY CRITERIA**

- A. The acoustic performance of the public address system shall meet guidelines for fire voice evacuation (EVAC) systems. To meet the guidelines the system has to be audible and intelligible.
- B. The Contractor shall meet the requirements of Audibility and Intelligibility per NFPA 72:1999
- C. Audibility can be quantified by achieving an averaged announcement level of 15db greater than the ambient background noise level (or 5db above the maximum background noise level exceeded for more than 60 seconds).
- D. Intelligibility can be quantified by meeting the Speech Transmission Index (STI) of 0.5 (as referenced in the IEC 60849).
- E. Contractor shall install a speakers & ambient sensing microphones to meet the specification provided by acoustic engineers.

### **1.4 COMMUNICATION SYSTEM ENCLOSURE AT EACH STATION SHALL CONTAIN THE FOLLOWING DEVICES**

- A. A control cabinet microphone for local “real time” announcements.
- B. A Public Address Station Controller Unit for remotely controlled “prerecorded” announcements, system monitoring, diagnostics, and local station control.
- C. A monitor panel/keyboard for viewing/monitoring of the SCU.
- D. Multi-channel Digital Signal Processor (DSP) unit which shall accept various microphone and line level inputs, provide Pre-amplified outputs, provide Ethernet connectivity for remote maintenance and diagnostics, audio matrix switching and provide high quality signal amplification necessary to drive station loudspeakers at desired sound pressure levels. Alarm monitoring shall provide notifications to the AIM Headend Software of service degradation and DSP health status.
- E. A 800 watt four Channel Amplifier with Ethernet connectivity protocol to allow local and remote control and monitoring from the local SCU & the OCC. Remote control abilities shall permit configuration and adjustments needed to provide high quality signal amplification necessary to drive station loudspeakers at desired sound pressure levels. Alarm monitoring shall provide notifications to the AIM Headend Software of service degradation and amplifier health status.
- F. Inter connection between DSP and amplifiers shall be capable of using Cobra Net VoIP.
- G. Ambient Noise Sensing Module: The Ambient Noise Sensing Module and Level Detector shall be integral to the DSP.

- H. An Ethernet interface Module shall included with the DSP and Amplifiers for VoIP connection and monitoring functions.
- I. A two Port VOIP Gateway to provide live audio over the MBTA network. The VoIP Gateway shall be fully integrated into the MBTA PA/VMS virtual switching matrix and shall provide connectivity from the remote microphones located outside the local passenger station. Local gateways shall be controlled remotely through the PA/VMS AIM software.
- J. A 24 port Ethernet Switch.
- K. A three port Router, if required, for leased services.
- L. All Ethernet networking equipment must be SNMP Managed.
- M. Document Drawer.

## **1.5 QUALITY ASSURANCE**

### **A. Contractor Qualifications**

1. Shall be primarily engaged in supply, installation, and maintenance of commercial duty sound systems.
2. Shall be authorized by the manufacturer of equipment supplied for the supply, installation, and maintenance of that equipment.
3. Shall be capable of providing a fully assembled, fully tested, and integrated PA/ESS cabinet.
4. Shall employ factory-trained personnel for assembly, installation, and maintenance of this system.
5. Shall maintain a service facility stocked with spare parts, service manuals, and test equipment sufficient to efficiently repair this system and its comprising elements.
6. Shall maintain its service facility within 25 miles of Chelsea.

### **B. Manufacturer Qualifications**

1. A firm whose primary function is to manufacture commercial duty sound products.
2. Pre qualifies contractors for supply, installation, and maintenance of products.
3. Furnish support services as follows:
  - a.) Contractor training;
  - b.) Periodic Contractor review for technical performance;
  - c.) Service and maintenance manuals, including schematic information and parts lists;
  - d.) Factory stock of replacement parts;
  - e.) Factory repair service.

### C. Equipment requirements

1. Shall be standard products employed in similar installations.
2. Shall have been available for installation over a period of two years or more.
3. Shall be factory tested before assembly into system to confirm products meet or exceed manufacturer parameters for:
  - a.) Functional capability and control range;
  - b.) Electrical gain;
  - c.) Self-generated noise;
  - d.) Frequency response;
  - e.) Distortion;
  - f.) Free from RFI and EMI.
4. Exception: Contractor fabricated assemblies shall be exempted from requirements of 1 and 2 above. Only assemblies specifically designated herein, as "Contractor Fabricated" shall be exempted.
5. Equipment rack and control panel sub-assemblies shall be fully integrated and tested before delivery to installation site. Test result shall be provided prior to installation. Testing shall include audio, control, Ethernet, and matrix switching functions. Testing shall include both local and remote functionality with the AIM Head End.

### D. References

1. National Electrical Code.
2. Massachusetts Electrical Code.
3. EIA/TIA
4. NFPA
5. IEEE

## 1.6 SUBMITTALS

- A. Submit the following to the engineer for approval before commencing acquisition or assembly of materials:
  1. Certification that the installing Contractor maintains a fully equipped service organization within 25 miles of Chelsea.
  2. Bill of materials proposed for this project, to include:
    - a.) Item's specification reference number;
    - b.) Item's specification description;
    - c.) Item's manufacturer and model number;
    - d.) Manufacturer descriptive literature for each item;
    - e.) Quantity of each item proposed;
    - f.) Underline all items proposed as alternates to that equipment specified.
- B. Contractor shall submit the following before commencing acquisition or assembly of materials:

1. AC power requirements for all equipment; Heat generated by all equipment when operating at 10 dB below full rated output, in BTU/HRS. Heat dissipation calculations for all equipment installed within equipment case showing rise above ambient temperature;
  2. Block diagrams showing proposed equipment interconnection;
  3. Proposed rack elevation;
  4. Details for Contractor fabricated items, to include:
    - a.) Drawings or samples illustrating proposed size, shape, panel layout, color, finish, labeling, and or pertinent characteristics;
    - b.) Electrical schematics and parts list;
    - c.) Technical descriptions of parts comprising fabrication.
- C. Contractor shall submit four copies of following information upon completion of installation:
1. Functional flow diagrams illustrating component connections, with switches, relays, controls, and cable designations referenced by number;
  2. Rack elevation;
  3. Nominal control settings illustrated as pictorial representations of equipment items' control panels.
  4. Fabrication details, with switches, relays, controls and or devices referenced to functional flow diagram.
  5. Data describing manufacturer-produced equipment, to include four bound copies of following:
    - a) Manufacturer's descriptive literature;
    - b) Manufacturer's operating manuals;
    - c) Manufacturer's servicing information including schematics and parts lists.
  6. System test and measurement data described in this Specification.
  7. Proposed mounting methods for loudspeakers and or items of substantial weight;
8. Loudspeaker orientations;
- D. The Contractor shall submit a plan to comply with the Audibility/Intelligibility system design provided under this specification for approval to the MBTA. Any exceptions or alternate installation plans shall be submitted prior to start of construction.
- E. Contractor shall provide 2 sets of, complete passenger station drawings and cabinet drawings along with maintenance manuals to be provided with cabinet at the time of installation. One set shall be turned over to the project manager or his designate the other shall remain with the public

address cabinet as part of the installation. OEM Manuals and Asbuilt drawings to be provided on CD, asbuilt drawings shall also be provided in a hard copy format.

## **1.7 TRAINING**

1. None required.

## **PART 2 – PRODUCTS**

### **2.1 GENERAL**

- A. Equipment specified herein shall be as manufactured by Crown, Lyle, Shure, Bogen, Cisco, Mulit Tech, Atlas, or approved equal.
- B. Procedures for submitting proposals for Contractor fabricated assemblies are described above.
- C. Loudspeaker Cable shall be one-pair, 16 AWG, copper stranded, nominal O.D. 0.255 inch.
- D. Microphone/Control Cable shall be: 4 conductor, 16 AWG, copper stranded, twisted pair aluminum polyester foil-shielded with drain wire, overall PVC jacket, and nominal O.D. 0.355 inch.
- E. Cable shall employ identical color-coding throughout system.
- F. Cable types as approved by the Engineer.
- G. The Amplifiers shall conform to UL 1480 for speaker circuit line monitoring.

### **2.2 FOUR CHANNEL POWER AMPLIFIER**

- |  |  |
|--|--|
| A. Rated Output:                                   | 200 w per channel 70.7 Volt                |
| B. Frequency Response:                             | ±0.25 dB. At 1 watt 20Hz to 20KHz          |
| C. Signal to Noise Ratio (20 Hz to 20 kHz):        | 105 dB A-weighted.                         |
| D. Total Harmonic Distortion from 20 Hz to 20 kHz: | < 0.1%.                                    |
| E. Damping Factor:                                 | 10 Hz to 100 Hz: > 3000.                   |
| F. Input Impedance (nominal):                      | 10 kilohms balanced, 5 kilohms unbalanced. |
| G. Maximum Input Level:                            | +20 dB input compression, +32 dB maximum.  |
| H. Load Impedance ohms                             | 2/4/8/16 ohms, Bridge Mono: 4/8/16         |
| I. Required AC Mains                               | 120V/60 Hz, 230V/50 Hz.                    |
| J. Dimensions:                                     | 19 in. W x 3.5 in. H x 14.25 in. D.        |

**Amplifier shall be Crown model CTS-4200CN or equivalent.**

### **2.3 DIGITAL SIGNAL PROCESSOR (DSP)**

- |                        |                                |
|------------------------|--------------------------------|
| A. Power Requirements: | 100VAC to 240 VAC, 24W nominal |
| B. Data Communication: | RS232                          |
| C. Data Format:        | Serial, binary, asynchronous   |
| D. Data Rate:          | 38.4K BAUD                     |

E. Input Gain Range:	+20 dBu to -1 2dBu
F. Digital Sampling:	24 bit, 48kHz
G. Input Impedance:	20kOhms balanced, 10kohms unbalanced
H. Dynamic Range:	Greater than 1 00dB (A-weighted, 20 Hz-20KHz)
I. Frequency Response:	20Hz-20kHz, $\pm 0.5$ dB
J. Output Impedance:	100 Ohms balanced 50 ohms unbalanced
K. Weight:	13 pounds, 4 ounces (6.1 kg)
L. Dimensions:	19"W, 16"D, 3.5"H

**DSP shall be Crown model PS 8810C or equivalent.**

#### **2.4 AUDIO MIXER**

- A. 8 inputs,
- B. 2 line outputs
- C. Balanced Phoenix-type mic/line inputs; RCA inputs
- D. Balanced Phoenix-type line outputs
- E. Any input can be sent to any output
- F. Independent Bass and Treble controls on each input
- G. Priority muting
- H. Built-in tone generator

**AUDIO MIXER shall be Crown model 28M or equivalent.**

#### **2.5 VOIP GATEWAY**

- |                     |  |
|---------------------|--|
| A. Number of Trunks | 2  |
| B. Signaling        | TI –CAS/ROBBED bit signaling clear channel     |
| C. Connection       | 1, 2 RJ.48                                     |
| D. Interface        | 10/100 Base-T                                  |
| E. Format           | Ethernet/SNAP                                  |
| F. Power            | 115v/240V 60 Hz                                |
| G. Protocols        | H323, V4, Sip, RTR SMTP                        |
| H. Bandwidth        | G.211, G.726, G727 G729 with voice compression |
| I. Management       | Web browser Windows SNMP                       |
| J. Dimensions       | 17.4"w x 1.75"h x 8.75d"                       |

**VoIP Gateway shall be MultiTech model MVP210 or equivalent.**

#### **2.6 CISCO 2950 SERIES INTELLIGENT ETHERNET SWITCHES**

Model number WS-C29850-24 or equivalent

#### **2.7 STATION CONTROLLER**

- A. ADEK 5U Rack mount SCU Computer
- B. 566-ATX-B Industrial 4U 19" Rack \ Desk Mount Case, w\ ATX 7-Slot + Dual 60MM exhaust fans rear panel, Force Vent with Air Filter, 2-5.25", 1-3.5", + 1-3.5"
- C. Internal Shock and Vibration protected drive bay, w\Lock Door, Dual USB on front CP, Full Handles, Black



- D. 500 Watt ATX Power Supply, PS2, 115-240V 47-63HZ 8-4A,
- E. MB-8650 P4 Socket 478 ATX Main Bd., Intel® 865G Chipset, 400/533/800 MHz FSB, Ultra DMA IDE, Supports Dual Channel DDR 333/400 SDRAM To 4 GB, On board Intel® Extreme Graphics VGA, 10/100/1000 LAN, 2xSATA-150 Ports, 8xUSB 2.0, CFII, Audio, AGP 8X/4X, 5-PCI, 2-ISA (one shared), 4-Channel DIO, 5xRS-232 & 1xRS-232\422\485 ports 16-byte FIFO buffer – (COM1 on-header), 8-Channel (TTL 4-In\4-Out) Digital I/O, PS/2 Keyboard, PS/2 Mouse port
- F. Pentium 4 HT 3.0GHz CPU, S478, 800MHz FSB, 1MB Cache
- G. 512 MB DDR400 RAM, PC3200
- H. 120 GB SATA2 Hard Drive
- I. PC-DVD CD-ROM IDE
- J. Microsoft Windows XP Pro
- K. ARINC's AIM CIS PDS and PAC software

**SCU shall be ADEK model G5-23-06-3 or equivalent.**

## **2.8 3 PORT Mini Mux with Router or approved equivalent**

- A. Line Rate 1.544 Mbps
- B. Framing D4/ESF (selectable)
- C. Line Code AMI/ B825 (selectable)
- D. Connector DA15P
- E. Input Signal DSX-1 from 0db to -26db W/albo
- F. Output Signal DSX-1w/0, -7.5-15db
- G. Power 120volts at 60Hz
- H. Dimensions 12"w x 1"h x 7"d

**Router shall be Cisco or equivalent.**

## **2.9 AMBIENT MICROPHONE – PRESSURE ZONE MICROPHONE**

- A. Operating voltage 12-48 volts phantom power
- B. Frequency 80 Hz to 10 kHz
- C. Power sensitivity -43db
- D. Connector XLRM
- E. Impedance 75 ohms balanced
- F. Current drain 4ma
- G. Sound Pressure 100 db SPL/3% THD
- H. Dimensions (approx) 4.5" x 2.5" x 2.0"

**Ambient Microphone shall be Crown model PZM-11LLWR or equivalent.**

## **2.10 UNIDIRECTIONAL MICROPHONE**

- a. Type Dynamic
- b. Frequency Response 300 Hz to 5000 Hz
- c. Power sensitivity -53db
- d. Cable Attached, 1.8 m(6 Ft), 4 conductor(2 shielded)

**Microphones shall be Shure 527B or equivalent**

## **2.11 CONNECTOR BLOCKS**

Connector blocks shall be Phoenix Contact Model 3036356 Din Rail Mounted 2.5 Twin MT

## 2.12 LOUDSPEAKERS Type I Loudspeaker

- A. The loudspeaker shall be an Atlas Model C803A (70.7v) or approved equivalent, with line matching transformer.

1. Speaker Size	8" diameter
2. Power Rating	16 watts RMS
3. Frequency Response	70Hz – 15.5 KHz
4. Sensitivity	98db peak
5. Impedance	Nominal 8 ohms
6. Cone Material	Treated Paper
7. Flex Density	10,600 Gauss
8. Voice Coil Diameter	1.0"
9. Weight	2.4 lbs.

### Type II Loudspeaker

- B. The loudspeaker shall be a Electro-Voice 309 Series (70V), or approved equivalent,

1. Speaker Size	8.13" d x 3.25"h
2. Power Rating	16 watts RMS
3. Frequency Response	85Hz – 18 KHz
4. Sensitivity	98db peak
5. Impedance	Nominal 8 ohms
6. Cone Material	Treated Paper
7. Flex Density	10,600 Gauss
8. Voice Coil Diameter	1"
9. Weight	3.3 lbs.

- C. The low frequency driver shall utilize a metal-alloy cone with deep-anodized surface treatment for rigidity and corrosion resistance. The cone shall provide a heat transfer element for the voice coil under high-power input. Compounded rubber cone surrounds shall be formulated to withstand all-environment installations, including salt spray, ultraviolet light (UV), heat, cold, and constant humidity. The voice coil will be centered via a high gauss, low viscosity magnetic fluid (ferrofluid), which increases the heat transfer rate from the voice coil under long-term high-power use. The magnetic fluid shall prevent corrosion from occurring in the magnet gap.

- D. The high frequency driver shall utilize an environmentally stable titanium diaphragm. Ferrofluid shall dampen the voice coil and assist in the heat transfer for higher power capability.

- E. Environmental testing shall ensure long-term operation in any weather. Specifications shall exceed Mil-Std-810E Test Methods for Temperature, Humidity, Ultra-Violet Light, and Salt Spray.

- F. The mounting bracket shall be designed with multiple angles to facilitate installation in corners or when angulation is required. An integral safety strap mounting point shall be included. The loudspeaker shall rotate, on its axis, a minimum of 180°. The bracket shall be formed from heavy-gauge aluminum (minimum 3mm thick), and finished with a scratch-resistant paint (color-matched to the enclosure).

- G. The input connectors for 8-ohm and 70-volt systems shall be gold-plated screws with integral clamping washers.
- H. The Contractor will be required to adapt the speaker, if needed, to the contract drawings with the approval of the MBTA Engineer.

### **Type III Loudspeaker**

- A. The loudspeaker shall be a Bogen Model SPT3OA, or approved equivalent, reentrant type horn loudspeaker. The frequency response shall be 225Hz to 14kHz. Rated power output shall be 30 watts, RMS continuous. Dispersion shall be 100°. Sound pressure level, measured four feet on axis with 30watt input @ 1000Hz, shall be at least 125dB.
- B. The unit shall incorporate a seven-position weather-sealed switch, to allow matching the loudspeaker to a 25V or 70V constant-voltage line. Power handling capacity shall be adjustable at 70V to 1.8, 3.7, 7.5, 15, or 30 watts, and at 25V to 1.8, 3.7, 7.5, or 15 watts. Impedance shall be adjustable to 2500, 1300, 666, 333, 167, 89, or 45 ohms.
- C. The loudspeaker shall include a self-aligning, field-replaceable diaphragm. Screw terminals shall be provided for connection to the audio line. A plastic cover shall be provided to protect the connectors and impedance selector switch, and provide strain relief for the audio line. An all-purpose mounting bracket shall provide precise positioning in the vertical and horizontal planes with a single adjustment. The bracket shall include banding slots to permit mounting the loudspeaker on beams or pillars. Bracket and loudspeaker shall be finished in textured mocha enamel. The unit shall measure 11" in diameter by 10-1/2"D.
 

1. Power Rating (RMS):	30 watts continuous, 40 watts equalized
2. Frequency Response	225Hz to 14kHz
3. Impedance:	25/70 volts
4. Sound Pressure Level	125dB ~ four feet on axis with 30 watt
5. Dispersion:	100 degree
6. Dimensions	11" Diameter x 10-1/2"d
- D. Weatherproof Equipment: Where equipment is exposed to the weather, provide items specifically designed and listed for such duty.

### **2.13 EQUIPMENT RACK CONTROL PANEL**

- A. Furnish and install paging selector switch, to monitor zone output audio.
- B. Furnish and install 19" x 5-1/4" x 1/8" aluminum rack mounted panel which meets or exceeds following requirements:
  - 1. Finish –brush texture and black anodized.
  - 2. Microphone – close-talking, hand-held, low impedance, push to talk, with normally shorted microphone element and normally open DC control contacts: Altec D9IP, Electro-Voice, Turner or approved equal.

3. Microphone – right angle cord-mounting Connector XLR-3M type: Switchcraft R3M, Cannon, AKG, or approved equal.
- C. Assembly shall be as follows:
1. Bolt barrier strip to rear of panel.
  2. Mount microphone clip with tamperproof hardware.
  3. Bolt microphone receptacle to panel.
  4. Terminate DC status indicators to barrier strip and microphone and DC control wiring to barrier strip. Terminate wiring to barrier strips with spade lugs. Solder all other connections

## **2.14 PRIORITY AND MUTING CIRCUIT**

- A. Priority and muting circuit shall sense triggering voltage from the Public Address Computer Control Circuits and Equipment Rack Control Panel. All priority muting shall be accomplished and configured through the DSP
- B. Priority and muting circuit shall prioritize audio inputs as determined by the MBTA.
- C. In the absence of a page announcement, priority and muting circuit shall:
1. Lift all source lines from mixer inputs
  2. Short all mixer input lines;
  3. Reduce all mixer input gains to 60 dB below full output.
- D. In presence of a page announcement, priority and muting circuit shall:
1. Terminate paging source to assigned mixer input;
  2. Lift short from assigned mixer input line;
  3. Restore gain of assigned mixer input channel.
- E. Upon conclusion of a paging announcement, priority and muting circuit shall restore amplifier to idle state.

## **2.15 AC POWER SUPPLY**

- A. Conductors – Furnish and install single conductor electrical wires, type THHW, moisture and heat resistant insulation, rated at 600 Vac, with Underwriter's Laboratories (UL) label, and printed throughout entire length, at two-foot intervals, with permanent identifying markers, indicating manufacturer's name, size, type and voltage.
- B. Raceways – Furnish and install electrical feeders installed in galvanized rigid steel conduit as shown on Contract Drawings.
- C. Circuit Breakers – Furnish and install non-magnetic, molded case type circuit breakers, rated at 600 Vac, with current rating and number of poles as shown on Contract Drawings.

- D. Power Distribution Panels – Power will be provided to each equipment case and PA equipment from a MBTA provided Distribution system.
- E. AC Power Outlets – Furnish and install 2 rack mounted multi-outlet strips providing 120 VAC, 60 Hz power within each equipment case.

## **2.16 EQUIPMENT CASE**

- A. Furnish and install Public Address equipment housed in an equipment case as specified on the Contract Drawings.
- B. Furnish and install Public Address equipment case with a thermostatically controlled and vent fan. Power to the heater and vent fan to be provided on separate circuits from the power distribution panel.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Utilize existing conduit as indicated on Contract Drawings. Where conduit is required under this Contract, furnish and install separate conduit for the following:
  - 1. AC Power
  - 2. Control Cable.
- B. Cable Dressing
  - 1. Cross power wiring only at right angles and with loop providing separation of at least six inches.
  - 2. Support lateral wiring to prevent contact with station appurtenances and to prevent stress.
  - 3. Protect connections within junction boxes with waterproof electrical tape.

### **3.2 GROUNDING**

- A. Provide equipment-grounding connections as required. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.
- B. Ground equipment, conductor, and cable shields to eliminate shock hazard and to minimize to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments. Equipment rack ground should be less than 1-ohm from central ground point. Measure, record, and report ground resistance.

### **3.3 TESTING**

- A. Test each device in presence of a manufacturer's representative. Upon completion of test, submit a certified test report to the Engineer.
- B. Any system deficiencies observed under testing shall be noted in certified test report. All deficiencies shall be corrected and system shall be retested. Submit a sequential certified test report to the Engineer.
- C. Test the complete system for Audibility and Intelligibility per NFPA 72:2010 with the Engineer.
- D. Test the complete system in the presence of the Engineer. If any deficiencies are observed, correct same as described herein. Submit as-built drawings, maintenance manuals, and spare parts to the Engineer one-week prior to final scheduled testing.
- E. The Engineer and Contractor shall conduct final Audibility and Intelligibility acceptance testing of Public Address System on a date established by the Engineer.

## **PART 4 MEASUREMENT AND PAYMENT**

### **4.01 GENERAL**

- B. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, of the Public Address System.

## **END OF SECTION**

**SECTION 16898**  
**COMMUNICATIONS SYSTEMS TESTS**

**PART 1 - DESCRIPTION**

**1.1 SCOPE**

- A. The work to be done under this section, and in conjunction with the other sections of this Specification, consists of the tests and inspections which shall be performed to demonstrate and certify that all systems, subsystems, assemblies, sub assemblies, interfaces and components provided, relocated or otherwise affected by the work performed for this Contract function properly, safely and are in compliance with these Specifications. Tests shall also be made to demonstrate that existing functioning systems affected by or adjacent to work performed as part of this Contract are not adversely impacted and function as originally intended.
- B. Tests and inspections shall be performed during the various phases of this Project, from installation of the various system elements up to and including final system configuration and programing. Tests and inspections shall consist of, but not be limited to factory tests, visual inspections, breakdown tests, wiring and fiber verification tests, continuity and signal loss tests, electrical isolation tests, voltage and current tests, equipment burn-in tests, timing tests, network tests, CCTV tests, Electronic Access Control System (EACS) security system component tests, integration tests, and overall system functional tests.
- C. Test Plan – The Contractor shall develop a comprehensive Test Plan that will lead to the certification for service of the systems installed and the work performed under this Contract. The Test Plan shall detail and employ a logical process of component inspections through to overall system functional tests with each inspection and test building on the previous, resulting in a thoroughly tested and integrated system installation. The Test Plan shall itemize and provide overall organization of the Factory Tests and supporting data, Inspection Procedures and data forms, Test Procedures and data forms, and the final Test Report and System Certification. The Test Plan shall be representative of the Contractors application and design to be installed under this Contract. The Test Plan shall also identify how to document and address discrepancies during inspections and testing. The Test Plan shall include a matrix based checklist verifying each test has been conducted with a pass /fail/expected results criteria.
- D. Factory Tests – The Contractor shall provide vendor factory test data and test procedures for review and approval by MassDOT-MBTA (MBTA). Where vendor test data is not available or if the vendor factory testing is deemed unacceptable, the Contractor shall provide a substitute solution that is acceptable to the MBTA.
- E. Inspection Procedures – The Contractor shall develop a comprehensive schedule of inspections for all elements and components being installed, including but not limited to cable, fiber, conduit, cases, junction boxes, terminations, breakers, splice boxes, assemblies and equipment. The Contractor shall provide detailed inspection data forms for the inspection of all elements and components in the installation, including all applicable requirements.
- F. Test Procedures – The Contractor shall develop comprehensive Test Procedures for all functional elements of the system as well as the system as a whole. At a minimum, each Test Procedure shall identify in detail, the purpose of the test, the equipment and system under

test, the method and process of performing the test such that each system and subsystem is sequenced through its required operation including the imposition of simulated conditions, the expected results of the test including definition of pass/fail criteria, the test equipment needed to perform the test, the staffing requirements needed to perform the test, and the approximate duration of the test.

- G. Test Report and System Certification – Immediately following the completion of all inspections and testing, and the system is considered by the MBTA to be in-service, the Contractor shall provide a Test Report and Letter of System Certification. The Test Report shall contain the original versions of the Test Plan, Factory Test documents, Inspection documents, Test Procedure and data documents, all discrepancies reports, their resolution and retest data, etc. The Letter of System Certification will be based on the successful completion of all tests and inspections as identified in the Test Report. With the Letter of System Certification, the Contractor will also be stating that the system installed meets all applicable requirements of the specification and plans, as well as all local, state and federal codes and regulations.
- H. Contractor Responsibility – Unless otherwise stated, all support, labor and technical expertise for the work identified in this section and other test sections is the responsibility of the Contractor. All materials, equipment and test gear necessary to support the requirements of these specifications are the responsibility of the Contractor.
- I. MBTA Witnessing – The MBTA reserves the right to witness all inspections and tests. The Contractor shall provide sufficient notice to the MBTA as to the schedule of inspections and tests to be performed. Tests will not be considered official unless the MBTA Project designee has witnessed the test or the MBTA has informed the Contractor that the MBTA will not be witnessing that specific test. Under no circumstances shall the Contractor use MBTA Operations support staff as test witnesses. Whether or not the MBTA witnesses the test does not relieve the Contractor from any other requirements of the Contract Documents.
- J. Test Failure – In the event the item under inspection or the system under test does not meet the applicable requirements, the Contractor shall make the necessary corrections to bring the item or system into compliance. The Contractor shall be responsible for all applicable testing or retesting. The Contractor shall fully document the process from discrepancy report, failure analysis, corrective action plan, through to data showing the successful completion of testing.
- K. Impacts of Testing on Application and Design – The Contractor shall be responsible for applying and installing system components so that they can be effectively and efficiently tested separately and then together as a connected and cohesive functioning system.

## **1.2 STANDARDS AND REGULATIONS**

- A. All standards referenced within the Contract documents, as well as all applicable local, state and federal codes shall be observed and adhered to for all inspections and testing.
- B. The Contractor shall make reference to all applicable requirements in their test and inspection procedures.
- C. If a conflict exists between standards and regulations as specified herein the most restrictive, in the opinion of the Engineer, shall govern. The Contractor shall immediately make the MBTA aware of any conflicts.



### **1.3 QUALITY ASSURANCE**

- A. The Contractor shall maintain and adhere to a quality control process with regard to tracking all test documentation, including the test plan, inspection procedures, test procedures, test data, discrepancies, etc. The Contractor shall submit their methods to the MBTA for review and approval.
- B. The Contractor's designated Quality Assurance Officer shall review for completeness and accuracy all test documents, including, but not limited to the Test Plan, Factory Test Data, Inspection Procedures, Test Procedures, Inspection Data Sheets, Test Data Sheets, etc. The Quality Assurance Officer shall date and sign all documents that they review. The Contractor shall identify their Quality Assurance Officer in their bid. The Quality Assurance Officer can have no other responsibilities on this Project. The Quality Assurance Officer shall have a minimum of ten (10) years of experience in electrical and systems application and inspection as well as knowledge of trends and innovations with regard to the systems and products being applied on this Project.
- C. Test equipment of the proper type, capacity, range and accuracy shall be supplied by the Contractor to perform the required tests and inspections. This equipment shall be in good working order and properly calibrated at the time the tests or inspections are conducted. The calibration of each instrument shall be certified by a recognized testing facility. Re-certification shall be conducted every 90 days or less. Out-of-date instruments will be considered non-certified. Tests conducted with non-certified instruments will be rejected. Tests that require the use of test equipment shall have the make, model and calibration date noted on the test data forms.

### **1.4 SUBMITTALS**

- A. All Submittals shall be made in the format and manner that is required by these Specifications and subsequent MBTA approved agreements. Unless otherwise stated all submittals from the Contractor shall be for MBTA review and approval.
- B. All Submittals shall have sufficient data and information so that they may be reviewed as "standalone" documents. All references must be provided or already be in possession of the MBTA.
- C. Approval of any submittals does not relieve the Contractor from the requirements of these specifications. The Contractor shall make separate and specific requests for approval on waiving any requirements of the Contract.
- D. Submittal Format – All Submittals for this section shall be made in compliance with all other requirements of these specifications. In addition, all Submittals for this Section shall also be made in electronic, .pdf format submitted on optical media such as a CD or DVD. Each Specification Section requiring a submittal shall have a single corresponding .pdf document.
- E. Test Plan – Within thirty (30) days of receiving the MBTA notice to proceed, the Contractor shall submit their Test Plan.
- F. Quality Assurance/Quality Control – Within thirty (30) days of receiving the MBTA notice to proceed, the Contractor submit their Quality Assurance/Quality Control procedures and processes, both general and specific to this Project.
- G. Factory Tests – Within forty five (45) days of receiving the MBTA notice to proceed, the Contractor shall submit their Factory Test Submittal.

- H. Installation Plans – Within twenty-five (25) days of receiving the MBTA notice to proceed, the Contractor shall submit Installation Plans. The Installation Plans shall identify the locations where system elements and components shall be installed as well as all cable, fiber and conduit routing. Subsequent versions of the Installation Plans shall be submitted as they are revised during the installation process to reflect actual field conditions.
- I. Inspection Procedures – Within forty-five (45) days of receiving the MBTA notice to proceed, the Contractor shall submit their Inspection Procedures, complete with corresponding data sheets.
- J. Test Procedures – Within thirty (30) days of receiving the MBTA notice to proceed, the Contractor shall submit their Test Procedures, complete with corresponding data sheets.
- K. Interim Reports – During the process of Inspection and Testing, The Contractor shall make submissions of interim test documents and result as defined in these Contract Documents.
- L. Test Report and System Certification – At no more than one (1) week after the completion of testing and MBTA assuming responsibility for the installed system(s), the Contractor shall submit the Test Report and System Certification letter signed by a principle of the prime Contractor, certifying that all necessary tests have been performed and that the system(s) successfully passed the tests.

## **PART 2 - PRODUCTS**

### **2.1 TEST EQUIPMENT AND MATERIALS**

- A. Relative to the systems being installed as a part of this Project, the Contractor shall supply and use the latest commercially available test equipment. Use of indirect testing methods resulting from a lack of having proper test equipment shall not be approved.
- B. All test instruments and equipment necessary to conduct the tests specified herein shall be available, ready-for-use not less than one week in advance of test need. Ready-for-use shall mean properly matched for test parameters, properly calibrated, sufficiently supplied with leads, probes, adapters, stands etc. necessary to conduct the particular test in a completely professional manner.
- C. All temporary or interim test related materials, special tools, connections, jumpers etc. shall be furnished and available not less than one week in advance of the test need.
- D. The Contractor shall maintain a complete backup set of test instruments and equipment in compliance with all other aspects of these specifications so that if any part of the primary test equipment fails, the back up equipment can be immediately used so that there will be no loss to the test schedule.

## **PART 3 - EXECUTION**

### **3.1 TEST PLAN**

- A. The Contractor shall develop and submit a comprehensive Test Plan that will provide a roadmap and structure for the process by which inspection and testing will be employed in certifying the installed system(s) for service. While the intent of this document is to provide an overview, it shall have sufficient detail so that the intent and completeness of the

envisioned inspections and testing can be understood by the MBTA prior to the development of the detailed inspection and test procedures.

- B. The Contractor shall take into account their application and integration of the selected products and subsystems when developing this Test Plan and subsequent support documents.
- C. The Test Plan will show how all elements and components of the installed systems will be completely tested. The Test Plan shall include logically formatted descriptions that identify all components to be inspected up to and including full system integration functional testing.
- D. The Contractor shall provide a comprehensive Quality Assurance/Quality Control policy and process for this Project. This policy and process shall be reflected in all aspects of inspection and testing.
- E. Format – The Contractor shall develop and provide a Test Plan that at a minimum contains the following. It is expected that the Contractor shall expand their Test Plan with any and all necessary detail for the application being installed on the Project:
  - 1. Test Plan Summary – A summary describing how the Contractor’s plan for testing will demonstrate that the installation will perform as intended and be in compliance with all sections of the specifications, drawings and applicable standards.
  - 2. Quality Assurance/Quality Control – The Contractor shall describe their method of providing and maintaining a high standard of quality with regard to inspection, testing and system certification on this Project. At a minimum, this section will summarize how tests and inspections will be performed in a consistent manner, as well as describing how all test documentation will be developed and maintained in a logical and documented format.
  - 3. Factory Test Procedures and Documentation – Within this section and subsections, the Contractor shall itemize all components and systems to be used on this project and identify if and how they will be inspected and tested by the manufacturer. For items that are not inspected or tested by the manufacturer, the Contractor shall describe their plans methods for inspecting and testing those items on an item-by-item basis.
  - 4. Inspection Procedures and Documentation – Within this section and subsections, the Contractor shall itemize all components and systems to be installed on this project and identify how they will be inspected onsite. This shall include inspection prior to installation as well as post installation inspection. Post installation inspection shall also include the Contractor’s method of installation verification against the latest revision of the approved Contractor’s Installation Plans.
  - 5. Inspection and Testing Outline – The Test Plan shall contain an outline of all inspections and tests to be performed with brief descriptions. The Contractor shall also provide graphical flow charts that identify the order of all inspections and tests based on dependencies as well as those actions that can be performed in parallel.
  - 6. The Contractor shall inspect and test all components and systems installed under this Contract. Any additional inspections or tests that are not defined herein, but in the opinion of the MBTA may be required due to the Contractor’s application and installation, shall be added, fully documented and performed by the Contractor at no additional cost or schedule extension. The Contractor shall adhere to the same requirements as those already identified in these specifications

### 3.2 QUALITY ASSURANCE/QUALITY CONTROL

- A. The Contractor shall provide and/or develop a comprehensive Quality Assurance/Quality Control Plan to be used in support of all inspections and testing as well as for installation and the selection of products.
- B. The Contractor may use their corporate Quality Assurance/Quality Control documents where they are applicable to this Project. New processes and procedures shall be created as required by the particular application and systems being installed on the Project.
- C. Format – The following represents the general format that the Quality Assurance/Quality Control documents should follow. It is expected that the Contractor shall expand their Quality Assurance/Quality Control plans and procedures with any and all necessary detail for the application being installed by this Project:
  - 1. Summary – The Contractor shall provide a brief summary outlining the goals and methods of maintaining Quality Assurance/Quality Control.
  - 2. Role and Responsibilities of the Contractor’s Quality Assurance Officer – The Contractor shall define the role and responsibilities of the Project Quality Assurance Officer. At a minimum, this person shall have authority over all Contractor work forces and system elements being installed.
  - 3. Standards Compliance – The Contractor shall identify, index and describe all standards relevant to the work being performed and the system elements being installed on this Project. The Contractor shall describe how compliance shall be maintained through inspections and tests.
  - 4. Methodology of Conducting Inspections and Tests – The Contractor shall describe their approach for maintaining a high degree of quality and consistency across all inspections and tests. The Contractor shall describe how this methodology shall be reflected in the Contractor’s test and inspection procedures.
  - 5. Inspection and Test Data – All Inspection and Test Data shall be recorded in formats submitted and approved by the MBTA. All test data shall contain all applicable cross references necessary for efficient tracking. Where possible, automated means of generating the test shall be used. This includes the use of test equipment capable of recording and outputting reports as well as screen capture and database reports from processor based systems. All test data shall allow for the documenting of the responsible party conducting the Inspection/Test, the MBTA witness, date, test equipment used, etc.
  - 6. Methodology of Developing, Maintaining and Tracking Test Documentation – The Contractor shall describe in detail their method for tracking and certifying all inspection and testing of system elements identified by the Test Plan and the Contract Documents. The process of maintaining all documentation shall be done using a logical approach and in order of dependency on previous tests. The Contractor’s Quality Assurance Officer shall be responsible for ensuring the completeness and accuracy of all test related documents.
  - 7. Discrepancies and Discrepancy Resolution – The Contractor shall develop a comprehensive plan for identifying, tracking and resolving to the MBTA’s satisfaction all discrepancies. The MBTA shall have final approval over the level of retest required for the resolution of any Discrepancies, in part or complete retest. Any system modifications made after completion of the applicable test procedure shall require the creation of a Discrepancy, including the follow on resolution and retest process by the Contractor.

- a. The Contractor shall develop a Discrepancy Report Tracking Form for the purposes of documenting any and all discrepancies identified during this Project. Each Discrepancy shall have a unique identification for ease of tracking.
- b. A Discrepancy shall be generated using the approved Discrepancy Report Tracking Form whenever an issue is detected during inspection/testing, whenever a system element does not meet the requirements of an inspection/test or if any party witnessing the inspection/test deems it appropriate to generate a Discrepancy Report for future resolution.
- c. The Contractor shall note on all Test Data Forms and Installation Plans where a discrepancy was initiated with a unique identifier and date for cross referencing and future resolution.
- d. Discrepancies resolved at the time of inspection/test shall be tracked as such. A discrepancy shall still be generated and will be given an initial status of resolved.
- e. Discrepancies requiring future efforts for resolution will be tracked until they are resolved.
- f. Closing of any/all discrepancies can only be done by the MBTA as an acknowledgement that they were satisfactorily resolved.
- g. The Contractor shall maintain for the duration of the Project a Discrepancy list. The Contractor shall provide a copy of this list at the request of the MBTA, during Project Progress Meetings, for field meetings specific to discrepancy resolution, and at any other time that they MBTA requires. The Discrepancy list shall be maintained in a Microsoft Excel Spreadsheet designed by the Contractor and approved by the MBTA. At a minimum, the spreadsheet shall contain the Discrepancy Report Tracking Form Number, date the discrepancy was generated, description of the discrepancy, status of the discrepancy (open, resolved, closed), date resolved, MBTA witness to the discrepancy resolution, date closed (by MBTA only).

### **3.3 FACTORY TEST PROCEDURES AND DOCUMENTATION**

- A. The Contractor shall develop a process to capture, document and catalogue any and all factory test and inspection data, as well as results for all system elements to be used on this Project.
- B. The Contractor shall acquire and provide to the MBTA the manufacturer's recommendations for the application of the product for the function that the Contractor intends on this project.
- C. The Contractor shall acquire and provide to the MBTA the test and inspection procedures used by the manufacturer's producing the system elements.
- D. The Contractor shall acquire and provide to the MBTA the manufacturer's Quality Assurance/Quality Control certifications as well as any relevant practices and procedures employed while producing and factory testing any of the system elements and components.
- E. The Contractor shall provide confirmation documentation that all system elements were factory tested and received a "passing" status in meeting all advertised specifications and tolerances. This information shall include signed proof of compliance by the vendor's Quality Assurance Officer.

- F. Format – The following represents the general format that the Factory Test documentation should follow. It is expected that the Contractor shall expand their Factory Test Procedures and Documentation with any and all necessary detail for the application being installed on this Project:
1. Summary – This section shall describe the purpose and general methods to be used for Factory Testing, as well as the documentation to be used and provided for tracking.
  2. Index – The index shall be a matrix documenting all system elements and components to be installed and used as part of the systems being deployed on this Project. At a minimum, each line item shall identify have a description of the component, manufacturer, part number, lot number, serial number, intended use, Factory Test pass/fail status, as well as page/tab references to the section specific to that item. This matrix will act as both an index/table of contents and a quick reference status as to the status of the items being provided and installed by the Contractor.
  3. System Element/Component 1 – This will be one of many sections. There shall be a section for each component being installed on this Project.
    - a. Sub Section 1 – Title Page for this system element/component – At a minimum shall identify the manufacturer, part number, lot number, serial number and intended use.
    - b. Sub Section 2 – Manufacturer's/Vendor's Test Procedure – At a minimum shall identify the manufacturer's/vendor's inspection and test procedure for this particular component, including the necessary pass/fail criteria.
    - c. Sub Section 3 – Manufacturer's/Vendor's Quality Assurance/Quality Control Process – At a minimum shall identify the manufacturer's/Vendor's QC/QA Plan and process.
    - d. Sub Section 4 – (first) Component Inspection and Test Data Sheets – At a minimum shall contain the inspection and/or test data sheet/form/report for each component being installed for this Project. There shall be a minimum of one test data sheet for each component.
    - e. Sub Section 5 – (second) Component Inspection and Test Data Sheets – At a minimum shall contain the inspection and/or test data sheet/form/report for each component being installed for this Project. There shall be a minimum of one test data sheet for each component.
    - f. A new Sub Section shall be added for each component/element/subsystem/etc.

### **3.4 INSPECTION PROCEDURES AND DOCUMENTATION**

- A. The Contractor shall develop Inspection Procedures that will guide and support the inspection of all components and systems elements as installed, relocated or re-tasked in their final location and as shown on the latest revision of the Contractor's Installation Plans.
- B. Inspection Procedures – The procedures for inspections shall be inclusive of all components and elements that make up the systems as defined by these specifications and drawings. There shall be an Inspection Procedure for each type of component and/or type of installation (conduit, camera, SES cabinet, etc.) The Procedure shall describe in detail why the installed system element is being inspected, how it will be inspected, and identify the features and characteristics of the component or its installation to be verified – check-off list.
- C. Inspection Data Forms and Test Copy of the plans – The Inspection Data Forms shall be developed by the Contractor and will be based on the Contractor's Inspection Procedure and

referenced to (based on) the most current revision of the Contractor's Installation Plans. The Inspection Data Forms shall provide a way to reference the applicable Inspection Photos. The Contractor shall also provide and maintain a sets of Installation Plans to be used as Test Copies of the Plans. Where more practical than using custom Inspection Data Forms the Test Copies of the plans will be used to document the results of Inspection. A separate set of Test Copy plans shall be used for each Inspection. Only the relevant pages are required. When completed, all Inspection Data Forms, Test Copies of the plans and corresponding inspection photos shall be combined into a standalone PDF document for each component.

- D. Inspection Photos – The Contractor shall electronically photograph all system elements as they are inspected. In the case of cable, fiber and conduit runs, video would be acceptable. All photos and video shall be properly labeled and referenced to the appropriate inspection Data Form. All photos and video shall become the property of the MBTA. All photos and video taken as part of the inspection and testing shall become part of the test data and record documents.
- E. External Routing – For all conduit, cable and fiber runs, the routing shall be verified against the Contractor's Installation Plans. Characteristics to be verified include, but are not limited to verification of products installed, means of installation and mounting, cable fill, bend radiuses, routing of wire ways, sealing of conduits, etc.
- F. Mounting – For all equipment, junction boxes, cabinets, racks, cases, etc., the installation shall be verified against the Contractor's Installation Plans, as well as all applicable standards and practices. Characteristics to be verified include, but are not limited to: mounting location, labeling (stenciling/nameplates), method of mounting, clearances, method of securing, etc.
- G. Local/Internal Elements – For the installation of all system elements as it relates to equipment racks, equipment internal to cabinets, etc., the installation shall be verified against the Contractor's Installation Plans, as well as all applicable standards and practices. Characteristics to be verified include, but are not limited to component mounting, cable entrances, cable isolation, wiring, fiber, strain relief, bend radius, grounding, terminations, mounting, tagging and labeling, etc.
- H. Impacts – All elements of the systems being installed under this Project shall be fully inspected to confirm that they are not and will not be impacted by existing infrastructure. Conversely, the existing systems and structures adjacent to the systems installed as part of this Project shall be checked to confirm that their operation or integrity is not, and can not be impacted by the newly installed systems. To comply with this requirement the Contractor shall make every effort to install the new system elements so that they do not coexist with existing infrastructure. Where proximities are tight, the Contractor, through the MBTA Project Office, shall involve the necessary MBTA departments or external utilities as needed to gain an understanding of the necessary criteria for isolation and/or possible approval for their design and application. The Contractor shall make no assumptions that their application and installation supersedes existing infrastructure functionality.
- I. Discrepancies – Discrepancy reports shall be generated for all situations where the Contractor's Installation Plans do not match the field conditions, where the Contractor's Installation Plans are lacking for information, or if the field conditions are considered to be unacceptable. The Contractor shall be responsible for updating all plans to reflect all details of the actual field conditions. Where the physical route, location or method of installation is determined to be unacceptable, the Contractor shall determine a new, more acceptable route, location or method, followed by updating the installation and/or plans as needed.

- J. Format – The following represents a sample of the Inspections to be performed and the general format that the Documentation should follow. It is expected that the Contractor will expand the required Inspection Procedures and Documentation with any and all necessary detail for complete and proper inspection of the application being installed on this Project:
1. Summary – This section shall describe the purpose and general methods to be used for the Inspection process, as well as the documentation to be used and provided for tracking.
  2. Index/Table of Contents – The Contractor shall create an Index/Table of Contents that identifies the Inspection Procedure for each type of system element and installation type. For example a common Inspection Procedure could be used for all camera installations so long as the test data forms allow for the unique identification of each camera and camera location.
  3. Dependencies – The Contractor shall identify and document any dependencies between Inspections that must be accounted for, or have been successfully concluded prior to a particular Inspection taking place. The Contractor shall represent this information in both a written description and with a block diagram indicating Inspections that must be performed in either a serial or parallel manner. The Contractor shall also identify any restrictions in the ability to conduct complete and detailed inspections for MBTA consideration and approval.
  4. Inspection Procedures – Using the following as examples the Contractor shall develop detailed Inspection Procedures according to their application and as required by these Contract Documents. The Inspection Procedures will be refined in the submittal review process with the MBTA. If while in the process of Inspection, it is determined by the MBTA that additional requirements and Inspection Procedures are needed, the Contractor shall generate those updates or additional procedures in compliance with the requirements of these Contract Documents.
    - a. Cable, Fiber, Conduit, etc, Routing and Installation Inspection – This procedure shall be designed and used to confirm that all cable, fiber, conduit, etc., runs are in accordance with all Contract requirements.
      - 1) Confirm that all Cable, Fiber, Conduit, etc. are installed as shown in the Contractor's Installation Plans, including routing, support method, transitions, end-points (rooms, Junction Boxes, Equipment Cabinets), etc.
      - 2) Confirm that the installation is properly and sufficiently supported. Where possible closely inspect and mechanically stress a sample of the support elements to ensure they are not lose or fail. All mounts that seem visually compromised shall be tested.
      - 3) Confirm that the Contractor used the submitted products only for the installation. All products shall be listed on the test data sheet for verification.
      - 4) Confirm that the installation does not interfere with any clearance envelopes. This includes but is not limited to train dynamic envelopes, public passage clearance, clearance for maintenance and other activities for the newly installed systems as well as existing infrastructure.
      - 5) Confirm that the installation does not interfere with architectural elements of any and all public spaces except where previously approved by the MBTA. The Contractor shall make submittals specifically identifying conflicts or issues with architectural elements.
      - 6) Confirm that the Cable/Fiber fill is appropriate and does not exceed standards.



- 7) Confirm mechanical isolation between low voltage and high voltage systems. No colocation within the same support or containment system.
  - 8) Confirm that where entrance and exits exist that there is proper application of anti-chaffing and mechanical strain relief for a high vibration environment.
  - 9) Verify that all components are as submitted and that there are no substitutions.
  - 10) The test data forms for this procedure shall be a combination of a check-off lists and a Test Copy of the Installation Plans for verification of the cable/fiber routing and transitions. Where the routing is confirmed, the Contractor shall trace the line over with a green pencil. Where the routing can not be confirmed or deviates from the Installation Plans, the Contractor shall mark the plans in Red Pencil and generate the necessary Discrepancy Reports. Any failures to pass inspections documented on the check-off lists shall also result in the Contractor generating a Discrepancy.
- b. Power Feed and Source Inspection – This procedure shall be designed and used to confirm that all power feeds and sources are as required for the application defined by the Contract Documents, manufacturer’s recommendations and as shown in the MBTA approved Contractor developed Installation Plans.
- 1) Confirm that the installation of all newly installed breaker panels is located as shown in the Installation Plans and in accordance with all code requirements.
  - 2) Confirm that the installation of all new breakers is installed in the location shown on the Installation Plans and that the capacity is appropriate for the expected load.
  - 3) Confirm that all wiring is properly sized, terminated, dressed, strain relieved, etc. Where possible verify the mechanical connection of all conductors by straining the wire.
  - 4) Verify that all components are as submitted and that there are no substitutions.
  - 5) Confirm that all panels, breakers, cables, wires, etc. are properly tagged and labeled with the appropriate nomenclature and description.
  - 6) The test data forms for this procedure shall be check-off lists with all components to be verified identified within the lists. Any failures to pass inspections documented on the check-off lists shall also result in the Contractor generating a Discrepancy.
- c. Cabinet, Junction Box Mounting Inspection – This procedure shall be designed and used to confirm that all cabinets, junction boxes and other devices are properly mounted at the locations as shown in the MBTA approved Contractor developed Installation Plans and as required by the Contract Documents.
- 1) Confirm that the installation of the newly installed Junction Box is located as shown on the Installation Plans.
  - 2) Confirm that the installation is sufficient for the weight and size of the Junction Box.
  - 3) Confirm that the components used in mounting the junction Box are of the proper material for the location (galvanized, stainless, etc.) and are the same as was submitted for use in this application.
  - 4) Confirm that the Junction Box door is secured properly and that the hinges, handle and locking system function as intended.
  - 5) Confirm that all cabling and conduit entrances are properly secured, sealed, de-burred, etc.

- 6) The test data forms for this procedure shall be check-off lists with all components to be verified identified within the lists. Any failures to pass inspections documented on the check-off lists shall also result in the Contractor generating a Discrepancy.
- d. Junction Box Local/Internal Installation and Wiring Inspection – This procedure shall be designed and used to confirm that all components and materials that make up a Junction Box are properly installed, terminated, tagged, labeled, secured, sealed, etc., in compliance with the Contract Documents, manufacturer’s recommendations and the MBTA approved Contractor developed Installation Plans.
- 1) Confirm that all cabling and conduit entrances are properly secured, sealed, deburred, etc.
  - 2) Confirm that the cabinet door, handle and locking mechanism are functioning properly and can be secured.
  - 3) Verify that all components are as submitted and that there are no substitutions.
  - 4) Confirm the installation of the Fiber Splice Panel. Check for proper make and model, as well as the method of installation against the Installation Plans. Check that it is securely mounted and properly protecting the fiber splices and terminations.
  - 5) Confirm that all wire terminations are properly made. Verify the mechanical integrity of the connections by straining the conductors and connectors. Check for loose or improperly tightened terminals.
  - 6) Verify the slack of all cables and fiber are properly dressed and that none of the bends exceeds the manufacturer’s recommendations for bend radius.
  - 7) Confirm that all wires, terminals, fibers, etc. are properly tagged and labeled with the appropriate nomenclature. Verify that the Junction Box is labeled (stenciled) according to the Installation Plans.
  - 8) The test data forms for this procedure shall be a combination of a check-off lists and a Test Copy of the Installation Plans for verification of the cable/fiber routing and transitions. Where the conductors and terminals are confirmed, the Contractor shall trace the line over with a green pencil. Where the conductors and terminals can not be confirmed or deviates from the Installation Plans, the Contractor shall mark the plans in Red Pencil and generate the necessary Discrepancy Reports. Any failures to pass inspections documented on the check-off lists shall also result in the Contractor generating a Discrepancy.
- e. Communications Equipment Enclosure Local/Internal Installation and Wiring Inspection – This procedure shall be designed and used to confirm that all system components, wiring, fiber, terminations, etc., are in compliance with the Contract Documents, manufacturer’s recommendations and the MBTA approved Contractor developed Installation Plans.
- 1) Confirm that all cabling and conduit entrances are properly secured, sealed, deburred, etc.
  - 2) Confirm that the cabinet door, handle and locking mechanism are functioning properly and can be secured.
  - 3) Verify that all components are as submitted and that there are no substitutions.

- 4) Confirm the installation of the Ethernet Network Switches. Check for proper make and model, as well as the method of installation against the Installation Plans. Verify that the Ethernet Switch is mechanically secured.
  - 5) Confirm the installation of the Fiber Splice Panel. Check for proper make and model, as well as the method of installation against the Installation Plans. Check that it is securely mounted and properly protecting the fiber splices and terminations.
  - 6) Confirm that all wire terminations are properly made. Verify the mechanical integrity of the connections by straining the conductors and connectors. Verify that all terminals are not loose or over tightened.
  - 7) Confirm that all equipment, wires, terminals, etc., are labeled and tagged with the appropriate nomenclature according to the Installation Plans. Verify that the SES cabinet is properly labeled (stenciled) according to the Installation Plans.
  - 8) Verify the slack of all cables and fiber are properly dressed and that none of the bends exceeds the manufacturer's recommendations for bend radius.
  - 9) The test data forms for this procedure shall be a combination of a check-off lists and a Test Copy of the Installation Plans for verification of the cable/fiber routing and transitions. Where the routing is confirmed, the Contractor shall trace the line over with a green pencil. Where the routing can not be confirmed or deviates from the Installation Plans, the Contractor shall mark the plans in Red Pencil and generate the necessary Discrepancy Reports. Any failures to pass inspections documented on the check-off lists shall also result in the Contractor generating a Discrepancy.
- f. Batteries and Battery Chargers – This procedure shall be designed and used to confirm that all batteries and battery chargers are properly installed and cabled in compliance with the Contract Documents, manufacturer's recommendations and the Contractor's application.
- 1) Confirm that the battery charger is as submitted and that there are no substitutions.
  - 2) Confirm that the battery charger is properly mounted and secured
  - 3) Confirm that the battery charger chassis is grounded
  - 4) Inspect the Inside of the battery charger and confirm that all wires, terminations, components, etc., are properly assembled and appear to be unused. Check terminations of external wires for proper tagging, termination, etc.
  - 5) Verify that the manufacturer's characteristics plate is secure to the face of the battery charger and that the stated values match the expected values for the application.
  - 6) Confirm that all cabling and conduit is installed as shown in the Installation Plans and as required by the application.
  - 7) Confirm that all cabling is of the proper size and as shown on the Installation Plans.

- 8) Confirm that the batteries are as submitted and that there are no substitutions.
  - 9) Confirm that the batteries are mechanically secured as shown in the Installation Plans and that they are housed in a properly sized battery tray.
  - 10) Confirm that the battery terminals and terminations are properly torqued and lubricated with conductive grease.
  - 11) Confirm that all equipment, wires, terminals, etc., are labeled and tagged with the appropriate nomenclature according to the Installation Plans. Confirm that the battery charger and battery bank are properly labeled.
  - 12) The test data forms for this procedure shall be a combination of a check-off lists and a Test Copy of the Installation Plans for verification of the cable routing and transitions. Where the routing is confirmed, the Contractor shall trace the line over with a green pencil. Where the routing can not be confirmed or deviates from the Installation Plans, the Contractor shall mark the plans in Red Pencil and generate the necessary Discrepancy Reports. Any failures to pass inspections documented on the check-off lists shall also result in the Contractor generating a Discrepancy.
- g. CCTV Camera Installation Inspection – This procedure shall be designed and used to confirm that all CCTV Cameras and associated components are properly installed in compliance with the Contract Documents, manufacturer's recommendations and the MBTA approved Contractor developed Installation Plans
- 1) Confirm that the CCTV Camera and the mounting system is as submitted and that no substitution has been made.
  - 2) Confirm that the CCTV Camera located as shown on the Installation Plans.
  - 3) Confirm that the Camera is properly mounted and secured as shown on the Installation Plans and as required by the Contract Documents. Generally verify that the camera is aimed in the proper direction and that it has an unobstructed view.
  - 4) Confirm that all equipment, wires, terminals, etc., are labeled and tagged with the Appropriate nomenclature according to the Installation Plans.
  - 5) The test data forms for this procedure shall be a combination of a check-off lists and a Test Copy of the Installation Plans for verification of the cable routing and transitions. Where the routing is confirmed, the Contractor shall trace the line over with a green pencil. Where the routing can not be confirmed or deviates from the Installation Plans, the Contractor shall mark the plans in Red Pencil and generate the necessary Discrepancy Reports. Any failures to pass inspections documented on the check-off lists shall also result in the Contractor generating a Discrepancy.
- h. Access Control Door Locking Strikes
- 1) Demonstrate all Access Control Door Locking Strikes are fully operational.

- i. Access Control Door Contacts
  - 1) Demonstrate all Access Control Door Contacts are fully operational.
- j. Access Control Card Readers
  - 1) Demonstrate all Access Control Door Card Readers are fully operational.

### **3.5 TEST PROCEDURES AND DOCUMENTATION**

- A. The Contractor shall develop Test Procedures that will guide and support the testing of all system elements and their functions as well as testing the system as a whole.
- B. Test Procedures – The Contractor shall develop Acceptance Test Procedures and methods that when performed will completely exercise each component and shall cause each installed system and subsystem to be sequenced through its required operations, including the imposition of simulated conditions to demonstrate that the installation in its final configuration complies with all specified design requirements and operational functions. All application software, firmware, settings databases, user interfaces, network settings, alignment, etc., shall be verified for compliance and will be the latest stable revision. Testing Procedures shall be developed for the newly installed systems as well as any existing systems that are impacted or are close enough in proximity to the newly installed systems as to warrant testing of the existing systems.
- C. The simultaneous recording of data for Test Procedures being performed simultaneously for efficiency shall be considered only if the Contractor demonstrates to the MBTA that the simultaneous performance of tests will not in any way degrade the test process or data in any way. The Contractor shall submit all necessary backup documentation within their Test Plan.
- D. Test Procedure Data Forms – The Test Procedure Data Forms shall be developed by the Contractor and will be based on the Contractor's Test Procedures and referenced to (based on) the Contractor's application and the Contractor Documents. The Test Procedure Data Forms shall make allowances for referencing electronic means of recording data and eventual combining of all test and configuration data into a standalone PDF file for each system element.
- E. Electronic Documentation – The Contractor shall make use of electronic documentation whenever possible. This includes but is not limited to screen dumps/prints, video, photos, data dumps, etc. This data shall serve as proof of configuration verification and testing. All electronic data shall become the property of the MBTA. All electronic data developed while testing shall become part of the test data and record documents.
- F. Impacts – All elements of the systems being installed under this Project shall be fully exercised and monitored to confirm that they are not and will not be impacted by existing systems. Conversely, the existing systems impacted by and adjacent to the systems installed as part of this Project shall be checked to confirm that their operation or integrity is not, and can not be impacted by the newly installed systems. To comply with this requirement the Contractor shall make every effort to install the new system elements so that they do not coexist with existing infrastructure. Where proximities are tight, the Contractor, through the MBTA Project Office, shall involve the necessary MBTA departments

or external utilities as needed to gain an understanding of the necessary criteria for isolation and/or possible approval for their design and application. The Contractor shall make no assumptions that their application and installation supersedes existing infrastructure functionality.

- G. Discrepancies – Discrepancy reports shall be generated for all situations where the system functionality of the Contractor's Installation does not match the expected results as defined in the test documentation, these Contract Documents, or if the functionality is considered to be unacceptable. The Contractor shall be responsible for updating all systems and system functionality as needed for the successful completion of all Acceptance Testing.
- H. Format – The following represents a sample of the Test Procedures to be performed and the general format that the Documentation should follow. It is expected that the Contractor will expand the required Test Procedures and Documentation with any and all necessary detail for complete and proper testing of the application being installed on this Project:
  - 1. Summary – This section shall describe the purpose and general methods to be used for the Acceptance Testing process, as well as the documentation to be used and provided for tracking.
  - 2. Index/Table of Contents – The Contractor shall create an Index/Table of Contents that identifies the Test Procedure for each type of functional component, subsystem as well as the overall system as a whole. For example a common Test Procedure could be used for all camera installations so long as the test data forms allow for the unique identification and recording of the configuration data of each camera.
  - 3. Dependencies – The Contractor shall identify any testing dependencies that must be accounted for, or have been successfully concluded prior to a particular Test taking place. The Contractor shall represent this information in both a written description and with a block diagram indicating Tests that must be performed in either a serial or parallel manner. The Contractor shall also identify any restrictions in the ability to conduct complete and detailed inspections for MBTA consideration and approval.
  - 4. Test Procedures – Using the following as examples, the Contractor shall develop detailed Test Procedures according to their application and as required by these Contract Documents. The Test Procedures will be refined in the submittal review process with the MBTA. If while in the process of Testing, it is determined by the MBTA that additional requirements and Test Procedures are needed, the Contractor shall generate those updates or additional procedures in compliance with the requirements of these Contract Documents.
    - a. Cable and Conductor Verification – This procedure shall be designed and used to confirm that all cable, conductors, splices, terminations, jumpers, etc., from end to end and section by section (between terminations), meet the requirements of these Contract Documents, the manufacturer's specifications, are capable of supporting the Contractor's application and have no unaccounted signal losses.
      - 1) The Contractor shall develop a procedure for performing an end-to-end line circuit test that verifies the continuity and integrity of

each conductor of the cable as well as determining that each cable and conductor is connected to the proper terminal. This procedure will ensure that there are no crosses within the cable as a result of factory splices. The Contractor shall confirm that all conductor identification is consistent throughout the cable. Cables with bad factory splices shall be replaced.

- 2) The Contractor shall develop a procedure to confirm that there are no crosses, shorts or grounds on any cables or conductors.
- 3) The Contractor shall develop a procedure for verifying all cable and conductor tags as indicated on the approved Installation Plans.
- 4) The Contractor shall develop test data forms for this procedure that are based on the approved Installation Plans and the Contractor's Application. Some of these data forms may be similar to typical "megger sheets". Other Test Data Forms shall be customized as needed by the Contractor's Application. Where possible the Contractor shall use test equipment that is capable of producing Test Data Forms/Reports that include all necessary test data for review and acceptance by the MBTA. This may include test equipment for the Ethernet cables and connections, test equipment for the power source cabling, etc. Any failure to be in compliance with the Test Procedure "pass" criteria shall result in the Contractor generating a Discrepancy.

b. Fiber Verification – This procedure shall be designed and used to confirm that all fiber strands, splices, terminations, jumpers, etc., from end to end and section by section (between terminations), meet the requirements of these Contract Documents, the manufacturer's specifications, are capable of supporting the functions of the Contractor's application and have no unaccounted signal losses.

- 1) Power Level – For each fiber strand, the Contractor shall perform a power level test where the power level injected and the power level received are documented at the frequencies required by the Contractor's Application and specified by the manufacturer. The Contractor shall use test equipment that produces a report for each fiber strand certifying that the fiber meets all applicable requirements.
- 2) OTDR – For each strand, the Contractor shall perform an Optical Time- Domain Reflectometer Test to ensure that there are no unexpected power losses and that the expected losses are within the required specifications. The Contractor shall use test equipment that produces a report for each fiber strand certifying that the fiber meets all applicable requirements.
- 3) During these tests the Contractor shall confirm that all connections are properly cleaned using an approved cleaning kit and properly connected. Each connection shall be stressed to confirm proper mechanical connectivity while the Power Level and OTDR tests are being conducted.
- 4) The test equipment being used shall be used to "certify" that the fiber meets the requirements of these Contract Documents and shall be properly calibrated. The test equipment shall be capable of directly

generating test data forms with all of the necessary data and graphs for review and acceptance by the MBTA.

- 5) Bit error rate (BER) – The Contractor shall develop a Test Procedure that shall allow confirm the ability of the fiber to carry data with minimal loss. The optical span BER shall be less than, or equal to,  $1 \times 10^{-9}$  on both voice and data grade applications.
  - 6) The Contractor shall develop Test Data Forms for this procedure that are based on the approved Installation Plans and the Contractor's Application. Where possible the Contractor shall use test equipment that is capable of producing Test Data Forms/Reports that include all necessary test data for review and acceptance by the MBTA. Any failure to be in compliance with the Test Procedure "pass" criteria shall result in the Contractor generating a Discrepancy.
- c. Grounding and Ground Resistance Test – To ensure that all installed, modified and relocated equipment is properly grounded, the Contractor shall develop a Ground Resistance Test to ensure that all ground busses, cables, etc., meet the necessary codes and standards.
- 1) The primary ground connection(s) shall be tested to confirm that they meet all applicable codes and standards. The Contractor shall identify and reference all applicable codes and standards in their Test Procedure. Also reference 16450 and 16876.
  - 2) All components and connections of the grounding systems shall be tested to confirm the ability to both ground and isolate from ground. This includes but is not limited to equipment racks, equipment cabinets, equipment mounted in racks, UPS's, cameras, networking equipment, power supplies, etc.
  - 3) The Contractor shall develop Test Data Forms for these procedures that are based on the approved Installation Plans and the Contractor's Application. Any failure to be in compliance with the Test Procedure "pass" criteria shall result in the Contractor generating a Discrepancy.
- d. Power Isolation and Power On Testing – To ensure that all system elements are properly powered, the Contractor shall develop a test procedure that confirms that all power feeds and buses are isolated from each other and ground where applicable. The test procedure shall also confirm that all system elements are fed from the proper source and that the loads have been accounted for with properly sized cabling and short circuit protection.
- 1) Power-Off Isolation Verification – This Test Procedure shall be performed prior to applying power to any of the systems or equipment installed or affected by this Project. All fuses and breakers shall be open.
  - 2) This test procedure shall be designed to confirm that all power feeds and busses are properly isolated and free from grounds or shorts. The Test Procedure shall identify the proper reference voltages, grounds, test points, etc.
  - 3) Power-On Isolation Verification – The Contractor shall develop a Test Procedure that shall be performed as part of power-on process



for the newly installed systems as well as any other systems the Contractor made modifications. This Procedure shall confirm that all power sources, busses and systems are functioning as intended, and that all voltages and currents are within expected parameters as calculated by the Contractor.

- 4) The Procedure shall require that each power source be brought online separately, verified and confirm that all other adjacent power busses and systems are clear of any stray or incorrect voltage. The Procedure shall also require that all voltages be verified at all sources and load points.
  - 5) After all power sources are brought online and verified, each piece of equipment shall be brought online. Prior to powering up any equipment the Procedure shall require verification of the appropriate voltage at the input of the component. As each component is brought online, a cursory check shall be done to confirm that all components are functioning as required and expected.
  - 6) After all equipment has been brought online and is determined to be properly functioning, the Procedure shall require the confirmation that all voltage and current levels are within the expected ranges at the sources and at the loads.
  - 7) The Contractor shall develop Test Data Forms for this procedure that are based on the approved Installation Plans and the Contractor's Application. Any failure to be in compliance with the Test Procedure "pass" criteria shall result in the Contractor generating a Discrepancy. The Test Data Forms shall be prefilled with all expected values for all test points, busses, loads, feeds and supplies.
- e. Backup Power and Battery Verification – Test Procedures will be developed to demonstrated and ensure that all battery and battery charging systems are functioning as designed and needed to support the loads according to the Contractor's Application and calculations.
- 1) The Contractor shall develop a Test Procedure that will demonstrate that all battery systems are sufficient to support the systems they are supporting for the time duration required. This test shall be done with the respective systems running at full capacity. During this test individual battery cell voltages shall be monitored and recorded.
  - 2) The Contractor shall develop a Test Procedure that will demonstrate that all systems supported by battery will not be harmed as the battery voltage drops below operating levels.
  - 3) The Contractor shall develop a Test Procedure that will demonstrate that the battery charging system is capable of supporting all working loads as well as the charging of batteries that have been fully discharged without overloading any power sources or feeds.
  - 4) The Contractor shall develop Test Data Forms for these procedures that are based on the approved Installation Plans and the Contractor's Application. Any failure to be in compliance with the Test Procedure "pass" criteria shall result in the Contractor

generating a Discrepancy. The Test Data Forms shall be prefilled with all expected time durations and values for all test points, busses, loads, feeds and supplies.

- f. Network Configuration and Connectivity – The Contractor shall develop comprehensive Test Procedures to demonstrate and ensure that all network systems and components are functioning as needed to support the applications as defined in these Contract Documents and by the Contractor’s application. The Procedures shall confirm that network components have been properly configured and that data flow and access is as intended.
  - 1) The Contractor shall confirm that the configuration of all network subsystems and components are as needed to support the data transmission of all applications being installed or affect by this Project.
  - 2) The Contractor shall demonstrate that all VLAN’s are properly setup and routed to the proper locations and ports. All ports shall be checked for network access, including the ability of unassigned ports to deny network access.
  - 3) All Network switches, VLAN’s, ports, etc. shall be exercised and tested to confirm that they will support reliable data transmission at the maximum designed data throughput with a Bit Error Rate (BER) not greater than  $1/10^{15}$ .
  - 4) The Contractor shall simulate and introduce various failures into the network to verify that the system works as designed and intended during the failure and after restoration of the system.
  - 5) The Contractor shall develop Test Data Forms for these procedures that are based on the approved Installation Plans and the Contractor’s Application. Any failure to be in compliance with the Test Procedure “pass” criteria shall result in the Contractor generating a Discrepancy. The Test Data Forms shall be prefilled with all expected results and values. The Contractor shall also electronically capture test data by using screen capture and reporting functions of the installed systems as well as appropriate test systems and equipment to capture the configuration, characteristics and performance of all network components. All electronically captured data shall be properly referenced to the appropriate device and manually acquired test data.
- g. CCTV Camera – To ensure that all CCTV Cameras are functioning as needed for the applications as defined in these Contract Documents and the Contractor’s application, the Contractor shall develop comprehensive test procedures that confirm the configuration of all cameras, shall exercise all cameras through their configured settings, shall confirm the camera’s view and angle, shall confirm that the network connection for each Camera is working error free, etc.
  - 1) The Test Procedure shall confirm all functional characteristics of the CCTV Cameras, including but not limited to frame rate, data streaming method, etc. The Test Procedure shall also that all CCTV

Camera components are using the latest stable revision of software, drivers, firmware, etc.

- 2) The Test Procedure shall confirm all location specific information is as expected, such as IP address, Camera Name
  - 3) The Test Procedure shall confirm that the CCTV Cameras view and angle are as required by the Contract Documents. The Contractor is responsible for making all necessary adjustments to ensure that the cameras function as intended in compliance with the Manufacturer's recommendations.
  - 4) The quality of the video shall be verified to ensure that all necessary detail in the view can be determined and identified.
  - 5) All abilities of the CCTV Cameras shall be fully exercised where applicable. This includes PTZ functions controlled from remote locations.
  - 6) The Contractor shall develop Test Data Forms for these procedures that are based on the approved Installation Plans and the Contractor's Application. Any failure to be in compliance with the Test Procedure "pass" criteria shall result in the Contractor generating a Discrepancy. The Test Data Forms shall be prefilled with all expected results and values. The Contractor shall also electronically capture sample video and electronic test data by using methods such as video recording, screen capture and reporting functions of the installed systems to document the configuration, characteristics and performance of all CCTV Cameras. The electronic test data shall be properly referenced to the CCTV Camera under test as well as the manually taken test data. Should the Contractor choose not use an electronic means of capturing the configuration data, or if the Contractor's application does not support this method, the Contractor shall manually record all configuration data for all CCTV Cameras as part of this Test Procedure.
- h. CCTV Head End Test – The Contractor shall develop test Procedures to ensure that all CCTV Cameras can be viewed and controlled from remote locations over the installed network. The Test Procedures shall require thoroughly exercising all cameras remotely and confirming their identifications and the database used to configure the system.
- 1) The installation of new, interface to existing and configuration Head End components shall be verified and tested according to the Contractor's application and the manufacturer's recommendations. All operating systems, application software and firmware shall be confirmed to be the latest stable revisions. All licensing shall be confirmed and shall allow for full development capabilities.
  - 2) The Test Procedure shall require that each camera be pulled up for display and verify that the identity of each CCTV Camera matches the expected location and view.
  - 3) All Head End user interface functions shall be tested, including but not limited to keyboard shortcuts, drop down menus and icons.
  - 4) The Test Procedure shall verify the quality of the video meets the intent and requirements of the Contract Documents.

- 5) All alarms and failures that the system is capable of detecting and acknowledging shall be tested from each CCTV Camera and confirmed at the Head End.
  - 6) The Contractor shall develop Test Data Forms for these procedures that are based on the approved Installation Plans and the Contractor's Application. Any failure to be in compliance with the Test Procedure "pass" criteria shall result in the Contractor generating a Discrepancy. The Test Data Forms shall be prefilled with all expected results and values. The Contractor shall also electronically capture sample video and electronic test data by using methods such as video recording, screen capture and reporting functions of the installed systems to document the configuration, characteristics and performance of all CCTV Camera Head End application functions. The electronic test data shall be properly referenced to the CCTV Camera and Head End function under test as well as the manually taken test data.
- i. Access Control System – The Contractor shall develop test procedures that fully exercises the Access Control System from each field device up to and including the remote user interfaces, and demonstrates that each component and the system as a whole functions as required by the Contract Documents.
- 1) Test Procedures shall be developed for each field component of the Access Control System, from the field controller and the attached devices and sensors, including but not limited to Access Control Panels, Door Controllers, etc. The Access Control Panels and Door Controllers shall be tested and exercised to show that they are configured and programmed to trigger alarms and allow access as required and programmed. All adjustments shall be made so that there are no nuisance alarms or notifications.
  - 2) The installation of new, interface to existing and configuration Head End components shall be verified and tested according to the Contractor's application and the manufacturer's recommendations. All operating systems, application software and firmware shall be confirmed to be the latest stable revisions. All licensing shall be confirmed and shall allow for full development capabilities.
  - 3) Test Procedures shall be developed for the Access Control System as a whole including verification of the Head End system hardware, databases, user interfaces, icons, etc. The database, user interface and action of icons shall be verified at the remote Head End as each field device is exercised. For example, EACS equipped doors shall alarm upon intrusion and unique alarm messages and icons shall be displayed in an alarm condition on the Head End console.
  - 4) All Head End user interface functions shall be tested, including but not limited to keyboard shortcuts, drop down menus and icons.
  - 5) The Contractor shall make all necessary adjustments and updates so that all components and the system as a whole function as intended by the Contract Documents.
  - 6) The Contractor shall develop Test Data Forms for these procedures that are based on the approved Installation Plans and the Contractor's Application. Any failure to be in compliance with the

Test Procedure “pass” criteria shall result in the Contractor generating a Discrepancy. The Test Data Forms shall be prefilled with all expected results and values. The Contractor shall also capture electronic test data by using methods such as screen capture and reporting functions of the installed systems to document the configuration, characteristics and performance of all Access Control System application functions. The electronic test data shall be properly referenced to the Access Control System Head End function under test as well as the manually taken test data.

- j. VidSys – The Contractor shall develop Test Procedures that fully exercise and confirm the components and functions of the VidSys System from each field device up to and including the Head End are functioning as required by these Contract Documents and the Contractor’s application. The Contractor is responsible for confirming that all existing functions of the VidSys System are not impacted.
  - 1) All device status signals (e.g. loss of connection, tamper, loss of power, etc.) shall be tested and verified to ensure that the correct status indications are displayed on the VidSys client in the remote locations. This shall include CCTV equipment, NVRs, Tunnel Portal Lasers, IP Video Encoders and other equipment supplied and installed by the Contractor.
  - 2) Test Procedures shall be developed to verify VidSys Head End hardware, databases, user interfaces, icons, licensing, etc.
  - 3) The Contractor shall make all necessary adjustments and updates so that all components and the system as a whole function as in intended by the Contract Documents.
  - 4) The Contractor shall develop Test Data Forms for these procedures that are based on the approved Installation Plans and the Contractor’s Application. Any failure to be in compliance with the Test Procedure “pass” criteria shall result in the Contractor generating a Discrepancy. The Test Data Forms shall be prefilled with all expected results and values. The Contractor shall also capture electronic test data by using methods such as screen capture and reporting functions of the installed systems to document the configuration, characteristics and performance of all VidSys application functions. The electronic test data shall be properly referenced to the VidSys Head End function under test as well as the manually taken test data.
- k. CCTV System Video Storage – The Contractor shall develop Test Procedures for confirming the functionality, capacity, speed, etc., of the Video Storage System to ensure that the system meets the requirements of these Contract Documents and the Contractor’s application. The Test Procedures shall require fully exercising all manufacturer published features and characteristics of the CCTV System Video Storage.
  - 1) Through the CCTV Head End System, the Video Storage System shall be fully exercised ensuring that all capabilities are functional.
  - 2) While performing testing of the Video Storage System, the network shall be fully monitored for any degradation or saturation

resulting from the increased traffic of retrieving and viewing stored video.

- 3) All user interface functions shall be tested, including but not limited to keyboard shortcuts, drop down menus and icons.
- 4) Video from each camera shall be retrieved and viewed so that the configuration of the stored video matches the field location, time stamping, etc.
- 5) The revision of all software, firmware, etc. shall be verified to be the latest stable versions.

- 6) The Contractor shall develop Test Data Forms for this procedure that are based on the approved Installation Plans and the Contractor's Application. Any failure to be in compliance with the Test Procedure "pass" criteria shall result in the Contractor generating a Discrepancy. The Test Data Forms shall be prefilled with all expected results and values. The Contractor shall also capture electronic test data by using methods such as video capture, screen capture and reporting functions of the installed systems to document the configuration, characteristics and performance of all Video Storage application functions. The electronic test data shall be properly referenced to the Video Storage function under test as well as the manually taken test data.

1. System Integration Test – The Contractor shall develop a test procedure that fully exercises the installed system as a whole, from each field device up to and including the user interfaces, demonstrating that the subsystems and components are properly interfaced and integrated as required by the Contractor's Approved Application and these Contract Documents. This includes integration across systems so that the activation of an alarm or detection in the field will result in the appropriate camera view being brought up for display along with the appropriate icons and logs displaying the required indications.

- 1) Confirm that all Head End systems and consoles are properly configured and have all of the necessary software, databases and access to the necessary field devices.
- 2) The Contractor shall verify and demonstrate during the System Integration Test that the performance, features and functions of all communications, control, video processing, recording and encoding equipment have been incorporated and can be controlled and device status monitored at all console locations. This includes testing all deployed CCTV cameras, fiber optic and coaxial transmission equipment (all channels), motion detectors, enclosure tamper switches, digital video recorders, video decoders, uninterruptible power supplies, etc.
- 3) The Contractor shall develop Test Data Forms for this procedure that are based on the approved Installation Plans and the Contractor's Application. Any failure to be in compliance with the Test Procedure "pass" criteria shall result in the Contractor generating a Discrepancy. The Test Data Forms shall be prefilled with all expected results and values. The Contractor shall also capture

electronic test data by using methods such as video capture, screen capture and reporting functions of the installed systems to document the configuration, characteristics and performance of all system functions. The electronic test data shall be properly referenced to the system function under test as well as the manually taken test data.

### **3.6 FINAL TEST REPORT AND SYSTEM CERTIFICATION**

- A. Final Test Report – Upon completion of all Inspections and Testing as well as the Successful resolution of all Discrepancies, the Contractor shall prepare and deliver the Final Test report to the MBTA for review and approval.
  - 1. The Final Test Report shall contain all test documentation and data, including but not limited to all marked up test procedures, test data, discrepancies and notes.
  - 2. The Final Test Report shall contain the original versions of the test documents as well as all final marked-up versions of the same documents.
  - 3. All test data and marked up documents shall be reviewed for accuracy and completeness by the Contractor's Quality Assurance Officer. The Quality Assurance Officer shall stamp, initial and date each page as being accurate and complete.
  - 4. The Final Test Report shall be formatted in a logical manner with all documents tabbed/book marked and cross referenced for ease of access. All relevant information, including Discrepancies shall be grouped with the Inspections and Acceptance Tests where they occurred.
  - 5. The Final Test Report shall be delivered in a both paper and electronic format. The electronic format shall be in Adobe PDF format and be book marked and word searchable for efficient access. All electronic data, photo and video files shall also be included and cross referenced.
- B. System Certification – Upon completion of all Inspections and Testing, and after sixty (60) days of functioning without failure or unscheduled interruption, the Contractor shall submit for review and acceptance, a Letter of System Certification. The Letter of System Certification shall state that the system has been successfully installed, placed in service and integrated into existing MBTA Operations and systems. It shall also state that the system as installed and applied by the Contractor, is in compliance with all applicable standards and codes of a "Life-Safety" system that is fully capable of supporting MBTA efforts for maintaining security and the safety of the MBTA ridership.

### **3.7 FACTORY TESTS AND INSPECTIONS**

- A. Testing and Inspections shall be done according to the manufacturer's recommendations and shall be in compliance with the manufacturer's Quality Assurance/Quality Control process.
- B. Each system element and component shall be inspected and tested at its point of manufacture. Evidence of this inspection and testing, including acceptability shall be indicated on the item where practicable.

- C. All system elements and equipment shall be 100 percent inspected and tested.

### **3.8 FIELD INSPECTION**

- A. The Contractor shall conduct a detailed field inspection to confirm the proper installation of all system elements and components. At a minimum the Field Inspection shall be conducted according to the requirements of these specifications as well as the MBTA approved Contractor developed Inspection Procedures, Inspection Data Forms, Test Plans and Installation Plans.
- B. Inspection Documents – Inspections will be conducted using the most recent MBTA approved revisions of the Inspection Procedures, Inspection Data Forms, Test Plans, Installation Plans, etc.
- C. Order of Inspection – Based on the dependencies identified in the flow chart developed by the Contractor, Inspections shall be conducted in the proper order, from the most basic elements working to the more complex systems.
- D. Inspection Schedule – It is the intent of the MBTA to witness all field Inspections. The Contractor shall provide sufficient notice for MBTA mobilization to witness the inspections. Notice shall be given to the MBTA in the form of a complete and detailed Inspection Schedule. At a minimum, the Inspection Schedule shall identify the system elements to be inspected, the location of the Inspection, any special requirements and concerns, the number of Contractor personnel required to perform the inspection, flagging requirements, etc.
- E. Inspection Completion – An Inspection shall not be started unless it can be completed. If an Inspection can not be completed in the same time period that it was started, the remainder of the inspection steps shall each have a Discrepancy assigned to them or the Inspection can be abandoned completely, to be done during another scheduled inspection.
- F. Inspection Documentation Updates – If while conducting Inspections it is determined that the Inspection Procedure, Data Forms, etc., require minor updates, they may be updated in the field if the MBTA representative is in agreement. In any case, a Discrepancy will be generated noting the pertinent information and the need for the update.
- G. Quality Assurance/Quality Control – The Contractor's Quality Assurance Officer shall log and review all Inspection and Discrepancy documents used and generated during the Inspection process. It will be the responsibility of the Quality Assurance Officer to confirm that all Inspections were conducted as required and intended. The Quality Assurance Officer shall sign-off on the completion of each Inspection Procedure for each component only after all documentation is complete, signed, dated and the resolution of all associated Discrepancies has been accepted and approved by the MBTA.
- H. Interim Reports – The Contractor shall submit preliminary Inspection reports to the MBTA for Review and Comment as each Inspection is completed. Interim Reports shall be submitted within one week of the completion of the Inspection.
- I. The Contractor shall prepare a final and official Inspection Report to be Submitted as part of the final Test Report and Certification.



### 3.9 FIELD ACCEPTANCE TESTING

- A. All inspection must be successfully completed and all Discrepancies resolved and closed for the respective system elements prior to scheduling Testing.
- B. The Contractor shall conduct Field Acceptance Testing to confirm the proper installation, configuration and programming of all system elements and functions. At a minimum the Field Acceptance Testing shall be conducted according to the requirements of these specifications as well as the MBTA approved, Contractor developed Test Procedures, Test Data Forms, Test Plans and Installation Plans.
- C. Acceptance Test Documents – Acceptance Testing will be conducted using the most recent MBTA approved revisions of the Test Procedures, Tests Data Forms, Test Plans, Installation Plans, etc.
- D. Order of Acceptance Testing – Based on the dependencies identified in the flow chart developed by the Contractor, Acceptance Tests shall be conducted in the proper order, from the most basic systems working up to a complete system functional test.
- E. Acceptance Test Schedule – It is the intent of the MBTA to witness all Acceptance Tests. The Contractor shall provide sufficient notice for MBTA mobilization to witness the Acceptance Tests. Notice shall be given to the MBTA in the form of a complete and detailed Acceptance Test Schedule. At a minimum, the Acceptance Test Schedule shall identify the systems to be tested, the location of the tests, any special requirements and concerns, the number of Contractor personnel required to perform the Acceptance Tests, flagging requirements, etc.
- F. Acceptance Test Completion – An Acceptance Test shall not be started unless it can be completed. If an Acceptance Test can not be completed in the same time period that it was started, the remainder of the Acceptance Test steps shall each have a Discrepancy assigned to them or the Acceptance Test can be abandoned completely, to be done during another scheduled time.
- G. Acceptance Test Documentation Updates – If while conducting Acceptance Testing it is determined that the Acceptance Test Procedure, Data Forms, etc., require minor updates, they may be updated in the field if the MBTA representative is in agreement. In any case, a Discrepancy will be generated noting the pertinent information and the need for the update.
- H. Quality Assurance/Quality Control – The Contractor's Quality Assurance Officer shall log and review all Acceptance Testing and Discrepancy documents used and generated during the Acceptance Testing process. It will be the responsibility of the Quality Assurance Officer to confirm that all Acceptance Tests were conducted as required and intended. The Quality Assurance Officer shall sign-off on the completion of each Acceptance Test Procedure for each system only after all documentation is complete, signed, dated and the resolution of all associated Discrepancies has been accepted and approved by the MBTA.
- I. Interim Reports – The Contractor shall submit preliminary Acceptance Test reports to the MBTA for Review and Comment as each Acceptance Test is completed. Interim Reports shall be submitted within one week of the completion of the Acceptance Test.

- J. The Contractor shall prepare a final and official Acceptance Test Report to be Submitted as part of the final Test Report and Certification.

### **3.10 FINAL TEST REPORT AND SYSTEM CERTIFICATION**

- A. Develop and deliver the Final Test Report as required by these Contract Documents to the MBTA for review and approval.
- B. Develop and deliver the Letter of System Certification to the MBTA for review and acceptance.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.1 GENERAL**

- A. Separate Measurement and Payment will not be made for work required under this Section, but all costs in connection, therefore, will be included in the Contract Lump Sum Price for Item No. 745.01 – Bus Rapid Transit Stations. The lump sum price shall include all materials, labor, tools and equipment incidental and necessary for the installation, complete in place, for the communications systems tests.

**END OF SECTION**